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PROVISIONAL APPLICATION FOR PATENT COVER SHEET (Small Entity)

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

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☐ *Additional inventors are being named on page 2 attached hereto*

TITLE OF THE INVENTION (280 characters max)

Stereoscopic Systems Based on Color Filters

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification	*Number of Pages*	27	☒ Small Entity Statement	
☒ Drawing(s)	*Number of Sheets*	21.	☐ Other (specify)	

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

☒ A check or money order is enclosed to cover the filing fees

☐ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 13-2166

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government

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☐ Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,

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USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

- Provisional Patent Specification -

Inventors:

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Invention:

Stereoscopic Systems Based on Color Filters

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(Docket No.: 3Ality-008)

STEREOSCOPIC SYSTEMS BASED ON COLOR FILTERS

The current application claims priority from United States Provisional Application 60/152,133 filed on September 7, 1999, United States Provisional Application 60/168,351 filed on December 1, 1999, United States Provisional Application 60/175,026 filed January 7, 2000, United States Provisional Application 60/178,390 filed January 27, 2000, and United States Provisional Application 60/185,764 filed February 29, 2000.

SPECIFICATION

Prior documents

The reader of this document is assumed to be familiar with

- U.S. Patent 5822117 to Kleinberger et al., and referred to in the following as "PAT" here incorporated by reference.
- PCT application WO 97/26577 dated 24 July 1997, and referred to in the following as "PCT" here incorporated by reference.
- U.S. Patent 2631496 to Miles P. Rehorn.

Note on the figures

Except as otherwise noted, all the figures of this document refer to systems as see from above. Thus elements of the figures represented by rectangles (such as element 101 in figure 1) generally represent vertical strips or similar objects in a plane understood to be perpendicular to the plane of the figure.

Figures 1, 2, and 4 present pairs of images contrasting two states of a same apparatus. To facilitate comparison, the right-hand image is presented as a mirror image (with appropriate changes) of the left-hand image. The discussion will nevertheless continue to refer to the placement of objects as would be appropriate in discussing the left-hand image. For example, eye 30 will be referred to as the left eye and eye 20 as the right eye, despite the fact that in the right-hand image 1b, a near-mirror-image of figure 1a, eye 30 actually appears to the right of eye 20.

Definitions

Terms used in this document and which are defined in the definitions section of PCT are to be understood as they are defined in PCT.

In the following paragraphs some additional terms are defined, and, for the convenience of the reader, additional explanatory material relating to some terms defined in PCT is also provided.

"light rotating means" is there defined as "means which change by 90 degrees the orientation of linearly polarized light. . ." In certain of the embodiments described below, light rotating means are used in contexts in which partial rotation of light (i.e. rotation in an amount greater or lesser than 90 degrees) is contemplated. The degree of rotation intended in the following will be clear in context.

"left image" and **"right image"** refer to the pair of images which together constitute a stereoscopic display pair, the former presenting a scene as it would appear to the left eye of an observer, the latter to the scene as it would appear to the right eye of an observer. Stereoscopic and autostereoscopic display systems generally seek to present a left image to a viewer's left eye and a right image to a viewer's right eye, and to prevent light from the left image from reaching the right eye and light from the right image from reaching the left eye.

"inappropriate image" refers to that image which, if seen by a particular eye, will interfere with or degrade the autostereoscopic effect. Thus with respect to the left eye, the right image is the inappropriate image, and with respect to the right eye, the left image is the inappropriate image. Similarly, the **"appropriate image"** refers to the left image with respect to the left eye, and the right image with respect to the right eye.

"our two-layer polarizer systems" refers to the systems described in PAT in figures 6 – 12 and in the accompanying text which relates to those figures

"classical parallax-barrier system" refers to the well-known system for autostereoscopy by which an optical barrier consisting of transparent and opaque vertical strips is interposed at a particular distance from a display, and the display presents side-by-side pixels from alternating sources, pixels from a left image alternating with pixels from a right image.

"movement-permissiv system" refers to the technique described in figures 32-33 of both PAT and PCT, and in figure 33a of PCT. This technique allows for a certain amount of movement of the viewer's head and eyes, without said movement causing degradation of the autostereoscopic effect nor of the quality of the display as it appears to the viewer. The movement-permissive system can be used in our two-layer polarizer systems, and in the classical parallax-barrier system, and in various other contexts. An additional advantage of the movement-permissive system is that systems in which it is incorporated are relatively indifferent to minor variations in the exact placement of, and optical qualities of the edges of, the various optical elements of which the systems are composed. For example, a parallax-barrier system including the movement-permissive system would be somewhat insensitive to minor errors of placement of the line of division between the transparent and the opaque segments of the parallax barrier.

"birefringent layer with individually switchable elements" refers to a layer with a plurality of individually controllable elements of "switchable light rotating means", (as that term is defined in PCT). In other words, it refers to any arrangement, such as that described in PAT figure 19, in which a device such as a liquid crystal with individually addressable areas is used in connection with a control system in such a way that at any given time, any particular configuration of all, some, or none of the individually switchable elements will turn the polarization orientation of light passing through them. As a common example, a "birefringent layer with individually switchable elements", when sandwiched between two flat polarizing layers, constitutes a popular form of notebook computer screen. For simplicity, the birefringent layers with individually switchable elements referred to in the following are drawn as if the individually addressable elements are parallel vertical strips, and this is indeed a convenient configuration for most of the embodiments described in the following, but it should be understood that this definition, and the embodiments incorporating birefringent layers with individually switchable elements as described in the following, are not limited to that particular configuration. Standard LCDs with two-dimensional arrays of addressable elements could be used, as well as other configurations.

"our mechanical head-tracking system" refers to the system described in PCT with reference to elements 134 and 134a of figure 18 therein.

"our electronic head-tracking system" refers to the system described in PCT with reference to figures 18-23, which uses a birefringent layer with individually switchable elements.

"our head-tracking systems" refers to either or both of our mechanical head-tracking system and our electronic head-tracking system.

"sweet spot" refers to that position or positions from which a viewer can see the stereoscopic image displayed by an autostereoscopic display. In the classical parallax-barrier system the sweet spot is intrinsically rather small. When that system is enhanced using our movement-permissive system, the sweet spot is enlarged.

"display pixels" refers to the physical pixel elements of display devices with fixed physical pixels, such as LCD display devices.

"image pixels" refers to picture elements of the left and right images, each of which may be displayed by zero, one, or several physical pixels on a display device which has physical pixels, or may be displayed, or not displayed, in some area of a display device which is not itself intrinsically divided into physical pixels.

"head-tracking sensor" is an apparatus capable of detecting and reporting information about the position of the viewers' eyes with respect to the display and the autostereoscopic apparatus. The head-tracking sensor will preferably be a detector of the position of the eyes of the viewer(s), but it may also be a detector of the position of the head of the viewer, or a detector of the position of an object worn on the head of the viewer, from which an estimate of the position of the eyes may be derived. Such detectors are available from various commercial sources. It may also be any other apparatus capable of supplying information relevant to the viewers' eye positions. For example, a device in the style of a television 'remote control' unit, through which a user might supply information about his head position by pressing buttons an a hand-held control device,

would be included in the definition of a "head-tracking sensor" as that term is used in this document.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Color Parallax Autostereoscopic System

Our PCT described (in figures 40 and 41 and with respect to various other figures) the use of a color filtration barrier in an autostereoscopic system. A system similar to that described therein, but with certain additional advantages, is described in the following.

The PCT figure 40 shows a situation in which a plurality of RGB triplets 1020 display at least a part of a left image, and these alternate a plurality of RGB triplets 1030 displaying at least a part of a right image. This arrangement is convenient to many types of displays, which display colors by showing combinations of primary colors combined in selected intensities. Moreover, many types of displays incorporate display pixels which actually consist of several distinct primary-color components, such as RGB triplets.

The system as described in PCT figure 40 has the advantage of providing our movement-permissive system yet requires less blocking of light than was called for by the methods presented in PCT figure 32 and 33a. Nevertheless that system has the disadvantage that each of the images, as seen by each of the eyes, is discontinuous: adjacent to each image pixel there is a dark area of at least equal size, which provides no light from that eye's image. The image consequently appears to be of relatively low resolution and low quality.

Figure 11 provides an arrangement which avoids this disadvantage, and which will consequently be superior in some applications. It is characterized by the fact that light from the two images is distributed over the display in such a way that small areas of the display surface will be presenting light from the left image in some color ranges, and also presenting light from the right image in some other color ranges. In this manner light from both images is spread across the display in a more evenly distributed manner, thereby minimizing the size of, or eliminating entirely, the areas of the display which do not present some light from any given image.

The system to be described may be contrasted to the classical parallax barrier system in which the blocking elements of the barrier layer line up in relation to the pixel elements of the display in such a way that the right eye sees pixels from the right image and the left eye sees pixels from

the left image, in a manner well known in the art. The arrangement described by figure 11 uses the parallax barrier technique in a novel way. In this embodiment the barrier consists not of transparent areas alternating with opaque areas, but rather of a layer 40 which combines two or more color barriers, each of which has areas blocking light of a particular spectral range alternating with areas transparent to that spectral range. When the light of various spectral ranges is distributed throughout the display as described above, and barriers to each spectral range are placed appropriately on layer 40, the result is that the visibility, to each of the eyes, of light from each color range, is controlled by a parallax barrier arrangement, yet light from the appropriate image from at least some part of the color spectrum is visible to each eye throughout the entire surface of the display.

Figure 11 can be used to illustrate a number of embodiments of this idea. In the following paragraphs the embodiments will be described in terms of the example of three-color displays, such as RGB displays, yet it should be understood that the specific example is for illustrative purposes only and that the invention is not limited to those particular colors, nor indeed to systems of three colors. Equivalent implementations might be made with two, four, five, or more color ranges. Moreover, in the examples given in the following elements which filter colors (whether by absorbing certain color ranges or by reflecting certain color ranges) are discussed as if they were physically fixed. Elements of variable optical characteristics with respect to color filtration could be used as well, on condition that at any given time their behavior approximates that described in the following for with respect to fixed color filtration systems.

In a first embodiment, we will consider the case where display 10 is capable of displaying all colors from either image at all points. If then display 10 were to display light of a first color range (e.g. red) from part of a right image in areas 102-104 and 108-110, and light of that color range from part of a left image in areas 105-107 and 111-113, and if areas of 42-44, 48-50, and 54-56 of layer 40 are transparent to light of that first color range, while areas 45-47 and 51-53 of layer 40 block light of that color from traversing them, then insofar as light of that first color range is concerned the arrangement constitutes the classic parallax barrier system for autostereoscopy. (Indeed, if all colors, rather than only the particular first range of color, were displayed, transmitted, and blocked in the aforementioned areas, then this would in fact be identical to the classical parallax barrier system.)

Other color ranges are also displayed on display 10 and transmitted or blocked by portions of layer 40, but according to this embodiment the blocking areas on layer 40 which block the several color ranges do not everywhere coincide. Similarly, on the display, for the left image and for the right image, at least some areas of the display displaying at least a second color range will not display a first color range, and at least some areas of the display displaying the second color range will not display the first color range. In a simple example according to this principle, red light from display 10 might be blocked by certain areas of layer 40, and green light from display 10 might be blocked by certain areas of layer 40, and the positions of the red-blocking areas and of the green-blocking areas would be different, in at least some areas of layer 40. Moreover there will be areas of the display which display red light from, say, the left image, and do not display, say, green light from that image, though they may display green light from the right image.

In the preferred implementation, the arrangement would incorporate the greatest possible differences in the placement of the various color ranges on display 10. Thus for example in a three-color display, if light from the first color range is displayed as stated above, then light from a second color range (e.g. green) from the right image might be displayed in areas 104-106 and 110-112 and light from that color range from the left image might be displayed in areas 101-103, 107-109 and 113-115, while light from a third color range (e.g. blue) from the right image would be displayed in 106-108 and 112-114 and light of that color range from the left image would be displayed in 103-105 and 109-111.

Of course, on any part of layer 40 in which more than one color range is required to be blocked, then at that point either individual filters may be placed one behind another to achieve this effect, or else a single filter which is opaque to both color ranges could be used.

On barrier layer 40, for each of the color ranges, areas which are transparent to that color range alternate with areas which block that color range, the pattern being repeated along the width of layer 40. The placement of the specific areas with respect to each particular color range is such as to constitute the classical parallax barrier system with respect to that particular color range, as was illustrated above for the first color range. Thus, given the placement of colors from the two images as stated in the previous paragraph, areas 44-46, 50-52 and 56-58 would be transparent to light of the second color range and areas 41-43, 47-49, and 53-55 would be opaque to that color range, and areas 46-48 and 52-54 would be transparent to light of the third color range, and areas 43-45, 49-51, and 55-57 would be opaque to that range. (The placement of

blocking areas on layer 40 specified in this and in the preceding paragraph will be referred to in the following as "filter arrangement A".)

Thus, with respect to each color range, layer 40 presents a parallax barrier, yet the barrier elements of the various color ranges are placed differently on layer 40. Consequently, while each eye sees the all the light from the image appropriate to it and does not see any light from the image inappropriate to it, yet there are no "holes" in the picture, no area of the display which fails to display at least some light from both left and right images. (Such a display will be called a "dense" display in the following.)

Of course, the technique just described may be combined with our movement-permissive system. That purpose might be accomplished in the manner described in PCT fig. 32-33a, by using opaque areas on layer 40, or areas which do not display light from either image on display 10. However a preferred implementation can be accomplished simply by reducing the width of each area of display 10 displaying each particular color range to an area smaller than the areas named above.

Figure 11 also illustrates this implementation. Consider the case in which the right image light of the first color range is displayed only in areas 103 and 109 (rather than in areas 102-104 and 108-110), while light of that color range from the left image is displayed only in areas 106 and 112 (rather than in areas 105-107 and 111-114). Similarly, right image light of the second color range is displayed at 105 and 111, left image light of the second color range is displayed at 102, 108, and 114, and light of the third color range of the right image is displayed at 107 and 113 and that of the left image and the third color range is displayed at 104 and 110. (This arrangement of display colors is called "display arrangement B" in the following.) Consider also that the color filter elements of layer 40 are as stated above with respect to the first embodiment, that is, layer 40 is constituted as described in "filter arrangement A."

It can be seen that reducing in size the display areas of each color range for each image, while leaving unchanged the size and placement of each of the areas on layer 40 which blocks light from a particular color range, creates precisely the situation described in PAT (figure 32) describing our movement-permissive system. Inspection of the figure will demonstrate that for each numbered area of display 10, its displayed color can be seen by the appropriate eye and not seen by the inappropriate eye, because areas of layer 40 transparent to that color stand between that particular area of the display and the appropriate eye, and areas of layer 40 which block that

color stand between that area of the display and the inappropriate eye. It can be seen as well that, for each numbered area of display 10, since three contiguous numbered areas of layer 40 permit the passage of light from that display area to the appropriate eye and three contiguous numbered areas of layer 40 prevent passage of light from that display area to the inappropriate eye, consequently considerable movement of eyes 20 and 30 could take place, left and right and forward and back, without that movement reducing the appropriate eye's ability to see all the light emanating from the particular display area, and without increasing the inappropriate eye's ability to see light from the particular display area. Similarly, movement permissiveness can also be accomplished by the opposite sort of arrangement: if two or three contiguous numbered areas from the display layer 10 are matched with only one numbered element of filter 40, for example, then permissiveness is also achieved, in a manner similar to that described in PCT figure 33a.

Since the discussion of the preceding paragraph relates to any random numbered area of display 10, it is clear that it applies equally well to display 10 as a whole. In other words, since it is true of each eye with respect to each numbered area of display 10 that eye can see light from the image which is appropriate and not see light from the inappropriate image, and that this continues to be the case when that eye moves moderately left and right and forward and back, then it is true of the arrangement as a whole that throughout the width of display 10 each eye of the viewer will see its appropriate image and only its appropriate image, and will continue to do so while moving moderately to the left and right and forward and back.. Thus the figure describes an autostereoscopic system which incorporates a form of our movement-permissive system yet in which the display presents no large gaps (none as large, for example, as an entire RGB triplet) in the displaying of the right and left images.

Of course, the specific configuration presented above is merely an example of the way in which a color display and color filter system can provide an autostereoscopic view without large gaps in the display of light from both images, while allowing for some freedom of motion on the part of the viewer. The arrangement might relate to two or four or five or more color ranges rather than three, and the display area displaying light from each color range might be either wider or narrower than that specified in the example.

The particular selection of color ranges and image sources described above does however present an interesting feature. If the first color range is taken to be red, the second green, and the third blue, then the situation described corresponds closely to popular types of RGB display

frequently used in televisions and liquid crystal displays (e.g. notebook computers), as well is in color monitors, where the "shadow mask" system used for displaying color in many CRT displays inherently divides the display area into areas of discrete color, which could then be directly aligned with a filter layer 40 at an appropriate distance and with appropriately placed and sized subdivision.

In any case, for any display system with RGB characteristics, the embodiment can be implemented by providing a layer 40 at appropriate distance with appropriately placed and sized blocking areas, and by displaying display pixels which mix the light from different color ranges from the left and right image pixels in an appropriate manner. For example, the display might present (in order) red from the left image, green from the right image, blue from the left image, red from the right image, green from the left image, blue from the right image, then again red from the left image, and so on, the pattern repeating itself across the width of the display. Stating the same thing in terms of RGB triplets, a first triplet would combine red from the left, green from the right, and blue from the left image, and the following triplet would combine red from the right, green from the left, and blue from the right image. Similar combinations could of course be made for systems based on two colors, four colors, or more.

The embodiments described above can also be applied to any display whose light source is comprised of any combination of colors however generated, if that display is first filtered to provide for regions of particular color ranges, as described in fig 41 of PCT.

The techniques described above can be used in the context of any technique used to create an impression of continuous color ranges by combining elements of particular color in controlled amounts. Many printing processes, for example, are of this nature. That is, the system is also applicable to context in which pigments are used to absorb color ranges from ambient light, and reflect back particular ranges of color. In particular, the arrangement described above can be applied to contexts such as the printing of books and magazines, billboard-type advertising displays, and so on. Printed pictures, having absorbed certain color ranges from the ambient light and reflected the unabsorbed color ranges, are seen by observers as having color in much the same manner as are displays which generate light, on condition of being well illuminated. Thus a printed image may display much the same color characteristics as a light-generating display source, and the method described above will work on it as well. In the case where the light illuminating the printed picture must pass through the color filters to reach the printed

matter, a light source which is both diffuse and sufficiently powerful will be required, but if such a light source is available the arrangement described will provide an autostereoscopic image as well. Specifically, a printed autostereoscopic image may be achieved by printing an image in two layers, with a first layer corresponding to the display 10 in figure 11, with colors from the left and right images distributed across the printed page as described with respect to display 10, then a transparent overlay of appropriate thickness (corresponding to the appropriate distance of layer 40 to display 10, which depends in turn on the width of the areas into which display 10 is divided, as described in figure 24 of PAT) placed on the image, and on that transparent layer, filter elements blocking particular colors, (described above as layer 40) are printed with transparent inks, or provided through any other printing or photographic or similar process.

In another example, the first layer might be produces as a transparency. Then both the image and the filter are tinted and transparent. The two layers, positioned appropriately one with respect to the other, can then be backlit, creating a striking autostereoscopic printed display.

In another embodiment, these principles can be applied also to the case of a stereoscopic projection system. We showed in PCT figure 38 that it is possible to project a pair of full-color images through a color filter subdivided into areas filtering particular colors, and view an autostereoscopic image as a result, on condition that the projectors and the viewers are positioned appropriately. Referring again to figure 11 here, consider a situation in which a full-color left image is projected from eye position 30 and a full-color right image is projected from eye position 20, both projecting towards a projection screen 12 placed in the position of display 10. It can easily be seen that if areas 43, 49, and 55 of layer 40 transmit only light of the first color range, areas 45, 51, and 57 transmit only light of the second color range, and areas 41, 47, and 53 transmit only light of the third color range, and all the even-numbered areas of layer 40 transmit no light at all, then the image projected onto the projection screen in the place of display 10 will have precisely the characteristics described above as "display arrangement B". (In the following this arrangement of layer 40 will be called "filter arrangement B".)

As we have seen above, an arrangement consisting of a display in display arrangement B, when seen through a layer 40 arranged as described in "filter arrangement A", is exactly the construction of the embodiment described above. Thus, if we project a pair of full-color images from appropriate positions through a layer 410 which is layer 40 arranged as "filter arrangement B" onto a projection screen 12, and then view that projection screen, again from appropriate

positions, through a layer 415 which is layer 40 arranged as "filter arrangement A", we will have a forward projection system with all the advantages of the embodiments described above, including a "dense" display as defined above, as well as the advantages of our movement-permissive system. (As shown in PCT figure 38, the geometry of these arrangements creates "sweet spots", and projectors of left and right images may be placed at any left and right eye positions.)

Note that the light allowed to pass through filter arrangement B is everywhere a subset of the light allowed to pass through filter arrangement A. That is, there is no light allowed to pass by filter arrangement B which would be blocked by filter arrangement A. Consequently it is possible to implement a projection system in which a layer 410 (layer 40 in filter arrangement A) substantially covers the projection screen (in a movie theater, for example), and to provide a layer 415 (another layer 40 in filter arrangement B) which filters light from the pair of projectors which are placed in positions comparable to eye positions 30 and 20, but which are substantially above or below the positions of the viewers. Layer 415 could then be placed out of the line of sight of the viewers, and the light from the projectors after being filtered by layer 415 would then pass without hindrance or substantial alteration through layer 410, reach screen 12, and be reflected back to the viewer, passing again through layer 410 but not through layer 415.

Implementing this embodiment in the case of a back projection system is simpler. In that case, screen 12 is a translucent back projection screen, the projectors are behind the screen, a layer 410 is behind screen 12, and a layer 415 is between the screen and the viewers.

Note that other patterns of color filtering may be used in the projection arrangement here described in place of the specific example given above. As an additional example, note that a filter layer altering, say, red, green, and blue stripes would produce an effect similar to that described with respect to two colors in figure 40 of PCT. Referring again to figure 11, note that on filter layer 40 if 56-57 and 50-51 are red, 54-55 are green, and 52-53 are blue, etc., and if a projector projecting a left image is placed at 30, then 113-114 will receive red light from the left image, 111-112 will receive green light from the left image, 109-110 will receive blue light from the left image. If a projector placed at 20 projects a right image, then 114 will receive green light from the right image and red light from the left image, 113 will receive blue light from the right

image and red light from the left, 112 has red from the right and green from the left, 111 has red from the right and green from the left, etc.

Advantages: This arrangement has some of the advantages of our "permissive" system: since the area on the screen is only slightly wider than the area on the filter for any color, moving the user's eyes sideways does lose light from the correct image. However since at no point are the color segments of the same color from the two images contiguous to each other, moving the user's eyes sideways a moderate amount does not cause him to see light from the wrong image.

Other arrangements of filter and image:

The system both of PCT and that described above has narrow pixels in front of wide filter areas, to get permissiveness. We can also do the opposite, wide pixel areas (e.g., in picture application): spread the red over 3 'pixels' and have a narrow slot for red to pass, this also gives permissiveness.

Printing and printing like application of the above:

We mentioned above the possibility of applying these methods to printing and similar processes. If the picture is an RGB image or the equivalent (some printing systems do something like RGB, print pixels in which separate colors are printed in separate places), then the method is the same as described above for adaptation to electronic display screens (appropriately modified, of course, to accommodate the specific pattern of color elements used by the particular printing system). In some printing systems (for example, the system used by Panorama Ltd. of Jerusalem, (using a Symbolic Signs Laser printer, on Infoclear film). which creates transparencies by 'printing' with laser activation of film pigments, two or more colors can be presented in the same area at the same time. This allows for other filter arrangements, since in that case there is no need to put e.g. only red into one area, only green into another etc. This allows, for example, a full-color system with only two filter areas, similar to the system described in PCT and relating to a color projection system, but in print medium. That particular system would have the advantage of high pixel density (hence a high quality image), though depending on the structure it might have low tolerance for movement of the viewer.

Other methods of getting narrow strips behind a wide filter in projection, in order to get the permissive system. Above described one method, that of projecting through a filter with narrow

color strips, then through a filter with wider color strips, with viewers viewing the projection through the wider filter only. This was to produce the permissive situation, where wide filter strips are used to view narrow color pixels. Note that in that situation, the first filter, through which the image is projected, accomplishes the color separation of what may have originated as a full-color image. If a full-color section of an image is projected through, say, a red filter, then a red 'pixel' results.

Here are some other ways to accomplish the same purpose, and get to the situation that narrow color elements are viewed through relatively wide filter areas. As seen above, that situation creates a wide viewing window in all of which the view can see the appropriate image without losing any light as he moves around, and from which he cannot see any of the inappropriate image.

A first method is simply to project narrow image pixels through the wide filter areas. In the method mentioned above we contemplated projecting a full-color image through color filter strips to get individual color pixels projected onto particular parts of the screen. In the method presented now, we cause the projection system to simply project color pixels as desired through the color filter and onto the projection screen, in predetermined positions with respect to the filter. This is easiest to implement in a computer-generated display. If for example to accomplish the stereoscopic representation of a scene, a particular area of the screen is required to have, say, a red pixel element of some particular intensity, then the computer-generated projector simply projects that pixel onto that spot. The invention here is the idea of coordinating that projection with the position of the various color strips on the filter, so as to generate the desired situation, namely a situation producing autostereoscopic vision with a high level of movement permissiveness of the viewer.

Another method of accomplishing this, which can be used independently or in conjunction with the previous method, is to project full color picture onto a screen with COLORED STRIPS on the screen. The idea is that if the screen is in color it will reflect only that color, so e.g. if you project red through a wide red filter onto a surface with red, green & blue strips, the red should reflect it and the green & blue should swallow it up. Therefore given a projection screen with colored strips, coordinated with a color filter layer with relatively wide color filter strips as described above, we can project colors through a filter area which is wider than the pixel size we desire to have on the screen, yet the pixels reflected from the screen will be of the desired size.

One application of this technique would be if we wished to project two full-color images from two projectors through a color filter as described above. We might position two projectors as described with respect to figure 38 of PCT, using a color filter with 'relatively wide' color filter regions as described above. If we used a normal projection screen this would produce a full-color autostereoscopic image (as described in PCT), yet would not create movement permissiveness, since the size of the projected color strips on the screen would be similar to the size of the filter areas through which they are viewed. If however we use the current idea of a projection screen with colored strips, one on which the strips are coordinated with the size and position of the filter area, then we would get as a result the permissive system described above.

For example, referring to figure 11, if areas 52, 53, and 54 or filter layer 40 were areas permitting the passage of red light (with 49-51 and 55-57 preventing the passage of red light), then if a left image is projected from position 30 and a right image is projected from position 20 (as explained with reference to figure 38 of PCT), then if layer 10 is a normal projection screen, red light from the left image would be projected onto areas 109-111 and red light from the right image onto areas 112-114. This would produce a relatively bright image, but a non-permissive system: any movement of the viewer's eyes from the appropriate viewing positions would cause crosstalk (an eye seeing light from an inappropriate image) and also would cause a reduction in the amount of light that eye receives from the appropriate image. The solution now proposed is for layer 10 to be a reflective projection screen which itself has colored strips, each strip appropriate to reflect light of some color range and absorb (or otherwise not reflect) light of other color ranges. In our example, if areas 110 and 113 are red-reflecting strips, but areas 109, 111, 112, and 114 are strips which do not reflect substantial amounts of red light, then the full-color images projected from positions 20 and 30 will result in a red strip from the left image appearing at 110 and a left strip from the right image appearing at 113. Since the right eye position will view area 113 through filter areas 52 and 53 and 54 (or the equivalent, elsewhere on layer 40), and the left eye position will view area 110 through filter areas 52 and 53 and 54 (or the equivalent, elsewhere on layer 40), each eye will see the appropriate image and the permissive system described above is in effect. Of course in this paragraph we have described the effect with respect to a particular color, but as described above, the same can be simultaneously accomplished with respect to other colors as well. Areas of color filtration on filter 40 can be made to overlap (as described above, for example with red-permissive filter areas at 52-54 and,

say, green permissive areas at, say, 54-56. Similarly, areas that reflect particular colors and do not reflect others can also be combined in similar fashion.

Another projection method is now described. In contrast to the previously disclosed methods, and other methods known to the art for producing stereoscopic (with glasses) or autostereoscopic (without glasses) displays using two projectors, the following method has the particular advantage of producing a color autostereoscopic display using only a single projector.

The single-projection autostereoscopic system is illustrated in figure 19. The PCT discussion of figure 38, and some of the discussion above, used a filter system (whether color or polarizing) at layer 40, projection of a left image from a left-eye position such as 30, and projection of a right-eye image from a right-eye position such as 20. (The discussion in PCT demonstrates that there in the filter systems under discussion there are multiple left eye and right eye positions, and that they are roughly equivalent with respect to projecting and viewing, so that if a left image is projected from a left-eye position then it is substantially visible from other left-eye positions and substantially not visible from other right-eye positions.

The current method contemplates projection of an image from a position which is neither the left-eye nor the right-eye position. In the preferred embodiment, the point of projection will be equidistant from the two, and at the same distance from the screen. In figure 19 this is position 25.

In the discussion of various display systems using color filters above, we made the point that the 'viewing window', that is the area within which the user can move to the left and to the right without seeing any of the inappropriate images, was unusually large. Nevertheless there exist, in those systems, areas which are not within the viewing window, because they are positions from which a viewer's eye might see light from both the left and the right image. We now utilize that fact, by projecting an image from such a position.

Figure 19 shows a projector at 25, equidistant from left eye position 30 and right-eye position 20. Areas 52-54, 46-48 etc. on filter 40 permit the passage of red light. Areas 50-52, 44-46, etc on filter 40 permit the passage of green light. Areas 54-56, 48-50, 42-44 permit the passage of blue light. (As elsewhere in this document, the number and selection and order of the particular colors in our example are chose as examples of the general principle, and the invention is not limited to these particular examples.)

As shown above, a display system using the filter here described and presenting red light from

a left image at 110 and 104, and red light from a right image at 107 and 113, and similarly green light from a left image at 114, 108, and 102, and green light from a right image at 111 and 105, and blue light from a left image at 112 and 106 and blue light from a right image at 109 and 103, would have the qualities discussed above, namely autostereoscopic viewing of a full-color image with a high degree of movement permissiveness of the viewer.

Lines 200, 210, 220, and 230 on the figure demonstrate how we produce that situation. A projector at 25 projects a single image towards screen 10. The image is subdivided in such a way that, for a given color, pixels from the left image are projected alongside pixels from the right image, alternating across the screen. Using red as an example, we see a red pixel from the left image projected between limits 200 and 210, and a red pixel from the right image projected between limits 220 and 230. The result is a red pixel from the left image on screen 10 in area 300, and a red pixel from the right image on screen 10 in position 400. In moving between the projector and the screen the left image pixel passes through the red-permissive area of the filter at 54, and the right image pixel passes through the red-permissive area of the filter at 48. Note that some inaccuracy is allowable, because any small extension of the left pixel to the right of area 300 will not affect the outcome, as it would be blocked by the red-blocking area of the filter at 49, 50, and 51, and any extension of the right pixel to the left of area 400 will similarly be blocked by the same red-blocking areas of filter 40.

Note that area 300 is entirely contained within area 110, and area 400 is entirely contained within area 107. This means that all the permissive characteristics described for this configuration of a color display system are in effect. Indeed, the fact that area 300 is smaller than area 110, and area 400 is smaller than area 107, actually increases the permissiveness of the system over and above that described earlier. Note also that one might encounter a situation in which the projected pixels extend somewhat in the other direction, that is area 300 might be expanded to cover the right-hand side of area 111, and area 400 might be expanded to cover the left-hand side of area 106. This might occur because of inaccuracy in the projection, or it might be done intentionally to increase the light intensity and color saturation of the projected image. In either case, the result would not be the destruction of the image and it's autostereoscopic, but merely some reduction in the degree of permissiveness presented by the system.

In the preceding discussion we related to red pixels. Clearly similar projection of appropriate green and blue pixels can be accomplished at the same time and in the same manner. A green

pixel from the left image would be visible to a left-eye position if it were projected through filter area 49 onto a part of screen area 108. A green pixel from the right image would be visible to a right-eye position if it were projected through filter area 46 onto a part of screen area 105. A blue pixel from the left image could be projected through filter area 54 onto screen area 112, etc. Thus, by dividing color pixels from the two images appropriately and projecting them into the correct areas of the screen through the areas of the filter allowing passage of light of that color, a full-color image visible in auto-stereoscopic mode is produced.

"Headtracking": aiming the apparatus at the eyes of the user:

Elsewhere we have described systems, which aim the 'sweet spot' (the area from which an eye can see the appropriate image and only the appropriate image) by modifying the position of the picture with respect to a fixed filter. Those methods can be used in various ways with autostereoscopic systems based on color filtration. Moreover, parallax barrier systems not dependant on color filtration, but which use image sources which provide independent color inputs which are combined by the eye into full color (e.g. RGB display systems) can achieve enhanced head tracking by relating to the sub-pixel composition of their images, and moving single subpixels (i.e. individual colors, rather than entire pixels) at a time. Further, the systems described above, because of their great permissiveness and wide viewing window, can benefit from simplified aiming systems. They are so permissive that neither great accuracy nor fine movements nor a multiplicity of possible positions is required.

The simplest method for aiming the apparatus towards particular eye positions as the viewer moves with respect to the display, using the color filter systems described above, is now presented. The as described, the viewing window using this system is extremely wide, on the order of 67% of the interpupilary distance ("IPD"), or more. This means that if a viewer's eye is exactly in the center of the viewing window, he can move something like 1/3 IPD to the left, and 1/3 IPD to the right, without seeing a light from the inappropriate image. If he continues to move beyond those limits, he first enters a small region where he can see some light from both images, and then enters a larger region where he again sees only light from one of the images, yet this time it is light from the inappropriate image. (That is, his left eye is now where his right eye should be, and his right eye is where his left eye should be.)

As noted, assuming a viewer whose IPD is close to the norm, most of the positions (at a given

distance from the screen) from which he can view the screen will not produce double images; rather, most positions will produce either a correct autostereoscopic image, or a "reversed parallax" image, where the each eye sees the inappropriate image. Basic aiming, then, can be accomplished simply by detecting when the viewer is in a position from which he would see reverse parallax images, and when this situation is detected, simply reverse the images on the display. That is, if the system detects that the viewer is in a position from which he will see an inappropriate image, then the display can be modified in such a way that each pixel position which would normally have displayed a pixel from the left image, will instead display a pixel from the right image, and vice versa. Note that if the system is a color filter system such as we described above, the switching is on a sub-pixel basis: each right image sub-pixel of a particular color is substituted for a left sub-pixel of that color, and vice versa. (We'll refer to this situation as the "reversed image" in the following.)

This system has the defect that it still allows for some areas in which the viewer can see double-images (some appropriate light, some inappropriate light), yet it has the advantage of great simplicity in that from most positions the viewer will see the correct image, the viewer will never see pure reversed parallax images, and the system functions with electronic switching (modifications to the image) alone, with no mechanical movement of any kind.

A modification of the above system solves the problem of the small areas where the viewer sees double images by introducing a mechanical moving element, yet one that is easier to produce and faster to use than competing systems. Here again we rely on the fact that the system enjoys a very large viewing window, and the viewer can move considerably to the right and left and forward and back without encountering inappropriate images and without losing any light from the appropriate image. We have described elsewhere (PCT) options in which a filter is continuously moved with respect to an image, so as to keep a viewers eyes within the 'sweet spot' viewing zone as he moves with respect to the display. A disadvantage of such systems is that they require exact movement of the filter or the display and fairly accurate determination of the viewer's eye positions.

Using a permissive filter system such as described above, the need for exact placement of the filter is somewhat relaxed: so long as the filter is in approximately the correct place, the system will allow him to see only the appropriate image. This makes it possible to use cheaper and simpler system for moving the filter. But with a certain minor compromise of quality, there is

a system which is easy to make and maintain, requires much simpler parts, but nevertheless provides an adequate solution for some applications. This system allows for only two positions of the filter, and switches rapidly and simply between them. Rather than exact positioning using a stepper motor or similar tool, a few springs and a couple of electro-magnets can do the trick. The essential idea is that when the viewing window is very wide (whether through the use of the color filter described above, or the use of the permissive system described in figures 31-33a of PCT, or using a lenticular system, or through any other means of producing an autostereoscopic system with a sufficiently large viewing window), it is then possible to use the system described in the preceding paragraph to reverse the images when necessary to avoid reverse parallax, and then to avoid positions where the viewer would be able to see both images rather than only the appropriate image, by flipping the filter position between two alternative positions. Referring to Figure 20, if the viewer's eyes are placed in such a way that his left eye, say, rather than being a position 30 is close to a position half-way between 30 and 20 (i.e. a position close to that of position 25 in figure 19), then his eyes will be brought back into the sweet spot if filter 40 were to move the length of one and a half filter strips to the right (or display 10 were to move the equivalent of one and a half display areas to the left (but normally it would be simpler and easier to move e.g. a piece of plastic at 40 with colored strips on it than e.g. an electronic display at 10)). Of course as stated above, one might move the filter the distance of one single filter area, or less, and thereby continuously track the user's eye position accurately. The point here is that with the large sweet spot produced by the system, such accurate aiming is not necessary.

Let's see what happens if the filter moves one and a half units to the right. If a red-permitting filter area were on areas 52, 53, and 54, and a red pixel from the left image were displayed in area 110 of screen 10, then lines 500 and 510 show the limits of the sweet spot with respect to that pixel for the left eye. We'll call this the filter's "first position". If the filter then moves one and a half units to the right that red-permitting area would move to cover the area previously covered from the middle of 53 through the middle of 50, and lines 520 and 530 show the limits of the sweet spot for the left eye with the new filter position, which we'll call the "second position". Note that there is some overlap: the viewing zones are wide enough so that there is an area (between 510 and 520), which is within the sweet spot from both positions.

If we now imagine a viewer's left eye starting from position 30 and moving towards the right, then any time within the period when his eye is between 510 and 520, the filter is moved to the

second position. His eye can now move all the way to line 530 without leaving the sweet spot. As he approaches line 530, the filter can be moved back to the first position and the images reversed, as explained above in the discussion of the avoidance of reverse parallax. In this manner he can move continuously to the right, with the filter simply flipping back and forth between its first and second positions, and the image flipping between the original image and the "reversed image". Under this system both eyes see the appropriate image at all times. The aiming system thus does have a mechanical component, but it is an extremely simple one.

Note that one possible implementation of the systems described above might be to not move the filter during rapid lateral movement of the viewer, but rather to depend on the fact that during major movement, (if the reversed image is switched on when appropriate) the preponderance of the time the viewer will be seeing the appropriate image only, and during a small fraction of the time he will be seeing the double image. To avoid an annoying clicking sound when the filter moves, it might be useful to cause it to move only when the viewer's position is relatively stable. This is an option which might be left to the choice of the user, or the choice of the application, some users and some uses requiring a quieter operation, others requiring 100% accuracy of the image at all times.

Mention that the screen is only moves a pixel and a half, which is to say less than a millimeter.

A more useful version of this would be to move the image with respect to the filter on a sub-pixel basis. Consider the case of an RGB display being seen through a standard parallax barrier (that is, a barrier which alternates opaque areas with transparent areas. Such a system would normally typically present one pixel (i.e. an RGB triplet) from a left image, and then one pixel (another RGB triplet) from a right image. Under that assumption, there is no simple way to move the image with respect to the filter in something approximating continuous motion.

Here we can, however, take advantage of the fact that many modern displays present the RGB triplets side by side in continuous fashion. Therefore if we relate to the sub-pixels (the individual colors) individually, without necessarily associating to them as triplets of colors, then it is possible to move the image sideways in a relatively gradual manner. Thus if the traditional manner of presenting the image would be something like this, where "RGB" represents colors from the left image and "rgb" colors from the right image, then though the traditional manner of presenting the pixels is

|RGB|rgb|RGB|rgb|RGB|rgb

it is equally possible to display an image whose pixels are composed of color elements from the left image and other color elements from the right image. Thus for example

RGb|rgB|RGb|rgB|RGb|rgB|

or

Rgb|rGB|Rgb|rGB|Rgb|rGB|

As we move from the first example above to the second, we have done the equivalent of removing the blue pixel from the right side of each triplet and placing it on the left side of the triplet. The display hardware does not physically move, but the portion of the display to be seen by any particular eye has moved slightly to the left. This corresponds to the movement of the eye of the viewer slightly to the right. Consequently this constitutes a method by which parallax barrier systems can produce aiming (head-tracking) with no moving parts. A slight modification of the above shows further advantages when used with our color filter system.

Using eye-position information to modify the image presented by a stereoscopic or autostereoscopic display, so as to produce the impression the viewer can see around the object. One annoying artifact of many stereoscopic systems is that as the user moves around the display, the image he sees seems to be always pointed towards him. One way to avoid this situation is to use a stereoscopic display which simultaneously shows images from a variety of viewpoints, so that as the viewer moves around the display he moves from the viewing zone of one image to that of another, then to a third and a fourth and so on. Many lenticular systems use this technique, for example.

A disadvantage of the technique is that if all the possible views must be shown at the same time, then under the techniques available for displaying the views today, each view will be a low-resolution image. Another disadvantage is that it requires the creation and simultaneous distribution (e.g. in a broadcast system) of multiple views of the object.

The alternative here proposed is appropriate for some systems, particularly those that are displaying computer-generated images. This is the case, for example, for all those systems which use the OpenGL / directX standard for creating views of images. These are essentially systems in which the characteristics of the object or scene to be viewed are know to the system, the viewer's virtual position in that space is known to the system, and the software or hardware

creates an image of the scene as it would appear to a viewer in that position. Graphics cards are available today to produce two such images, one displaced slightly sideways with respect to the other, so as to be able to display a stereo pair of images for a stereoscopic display.

Above, and elsewhere, we discussed the use of detectors of the eye-position of a viewer or viewers to modify the functioning of an autostereoscopic display so as to make it visible to the viewer from a variety of positions. The system proposed now is simply to use the same detected information about the position of the viewer to modify the images generated, using methods such as those used by the OpenGL/DirectX standard. A system using this technique would not only (if autostereoscopic) use eye-tracking to keep the image visible as the user changes position, but also to change the virtual position of the user with respect to the object being displayed. Thus if the viewer moves to the left, the image generated and displayed would be of the object being viewed, as seen from further to the left. (This technique of course can also be used with systems which do not require eye-tracking information for any other purpose, e.g. system which use polarizing glasses and do not need to adapt the display to the position of the user in order for the stereo effect to be visible.)

System for producing mixed-color signals on-the-fly from two signal input.

Several of the systems above call for a particular distribution of pixels and/or subpixels (color elements of pixels) across the face of a display.

In a digital context this is trivial to produce: given a pair of images presented as arrays of pixels, computing means can easily create a new array that combines information from the two input arrays in the desired format.

But in an analog signal context (e.g. analog television signals) this is less trivial. One possibility is to convert to digital representation, combine the images, and reconvert to analog. But in the context of a CRT-based television or similar system, here is another possibility. If we assume that there are two signal sources each representing one eye's viewpoint, then using an oscillator powering a switch, rapidly switch from one analog signal source to the other during the horizontal scan phase which puts the signal on the screen. Thus at one moment the signal comes from the right image, at another from the left, then the right, then the left, etc. If the speed of the oscillator is set to correspond to the pixel density (e.g. the density of the dots on the CRT color mask, or the equivalent), then the result can be that each RGB triplet gets its info from a different image from that of its immediate neighbor. Further, if the color signals are available

independently, then control of the phase relationships between the oscillators controlling the source of the signals of each individual color will make it possible to create the pattern of colors appropriate to our mixed-color filter such as is described above, as well as that appropriate to our alternating-color filter described in the context of figure 40 of PCT.

In the head tracking methods described in the PCT, the active elements of the two layers have to be the size of the whole screen. This presents a problem when one wants to use this system on a very large screen. The prices for active elements of a very large size are very high. To solve this, we need a system that will provide a solution that will keep the active elements small, and still allows the use of head tracking.

Figure 21 is an example of such a system, and is not meant to constrain the invention, and is only an example of how modifications can be made in our original technology, in order to get at the same results.

Described in the figure is a rear projection display, to which our system has been added. The basic components of a rear projection system are the projector 5010 and the rear projection screen 5040. To these we add a static polarizing layer 5050, made of strips 5060 alternating with 5070, which have an orthogonally oriented plane of polarization. Between the projector 5010 and the projection screen 5040, we place an active element 5030 with a single uniform polarizing layer 5020, placed between the projector 5010 and element 5030. Note that if the projector 5010 is an LCD projector, it already has a polarizer in the appropriate position, and there is no need to add another polarizer 5020. One last layer is an LC shutter 5200, which is placed between the active layer 5030 and the screen 5040, or between screen 5040 and static layer 5050.

Active layer 5030 is made of an addressable array and can be made into strips. (An alternative is to have the active layer 5030 made of addressable strips, without vertical addressability). For the example, let us say that we have turned off pixels 5100, 5140, 5150, 5160, and we have turned on pixels 5110, 5120, 5130, and 5170. Light moving through polarizer 5020 is polarized uniformly in one plane. If it then goes through an active region of layer 5030 (e.g. pixels 5110-5130), its plane of polarization is not changed, and will create a polarized light region on the rear

projection screen 5040, of the same orientation. If, on the other hand, it goes through a section of layer 5030 that is not activated (e.g. 5140-5160), light is turned by 90 degrees, and makes a light region on the screen of a plane of polarization orthogonal to the previous polarization. Thus, if we make strips of pixels on layer 5030 that are active, alternating with strips of pixels that are inactive, we get a pattern of polarized light on the rear projection screen 5040 similar to the static layer 5050. If the planes of polarization of layers 5030 and 5050 are made to be of the same / orthogonal orientation, and the size of the strips on layers 5030, 5050 are set appropriately, we get a system identical to the original system as described in the PCT, where the system can track the viewer's movement and adapt so that he can still see the image correctly, despite his movement. With the shutter layer, the system is able to switch which eye sees which part of the screen and this enables us to show the same parts of the screen to both eyes, in a sequential manner.

This system enables us (using information received from an external eye location device) to do head tracking, by turning on a pixel on one side, and turning one off on the other. For example, we form a 3 pixel strip by turning on pixel columns 5110, 5120, 5130, while leaving off pixels 5100 and 5140, 5150, 5160 etc. If the viewer moves to the left, we can turn pixel 5100, 5170 on and turn off pixel 5160. In effect, we've moved the strip one pixel to the left, and the viewer is again in the right location.

Note that layer 5030 can be placed very close to the projector 5010, and thus can be very small. This reduces significantly the manufacturing cost.

This system can also be made without the shutter element 5200. This element has the effect of reversing the state of layer 5030 as described in detail in the PCT. If we want to remove this element, layer 5030 will need to reverse it's state itself (e.g. in the first state, pixels 5100, 5140, 5150, 5160 are on, and pixels 5110, 5120, 5130, 5170 are off. In the second state, pixels 5100, 5140, 5150, 5160 are off, and pixels 5110, 5120, 5130, 5170 are on). In this way, the effect of the two layers (the active layer 5030 as projected on screen 5040 and the passive layer 5050 [in which e.g. one eye sees all the screen and one eye sees nothing, or any other combination] is reversed [e.g. in the first state the left eye sees the whole screen and the right eye sees nothing,

and in the second state the right eye sees the entire screen and the left eye sees nothing]). The areas previously seen by the left eye are now seen by the right eye, and the areas previously seen by the right eye are now seen by the left eye. Similarly, the areas blocked from view by the left eye are now blocked from the view of the right eye, and the areas previously blocked by the right eye are now blocked from the view of the left eye. If layer 5030 is capable of switching fast enough, and it is switched in the same way as layer 5200 would be switched, (i.e. at the same speed and using the same source signal) both eyes would be able to see the whole screen in a sequential manner.

Docket No.
3Ality-008

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Stereoscopic Systems Based on Color Filters

the specification of which

(check one)

☒ is attached hereto.
☐ was filed on __________ as United States Application No. or PCT International Application Number __________
and was amended on __________
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
(Number)	(Country)	(Day/Month/Year Filed)	☐
(Number)	(Country)	(Day/Month/Year Filed)	☐
(Number)	(Country)	(Day/Month/Year Filed)	☐

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I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)	(Filing Date)
60/185,764	09/07/1999
60/178,390	01/27/2000
60/168,351	12/01/99
60/152,133	09/07/1999
60/175,026	1/07/2000

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or S ction 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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Guy E. Matthews, Reg. No. 24,173
William E. Johnson, Reg. No. 22,719
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Gary R. Maze, 713-355-4200

Full name of sole or first inventor **Paul Kleinberger**	
Sole or first inventor's signature Paul Kleinberger	Date 7/12/00
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Citizenship **United States of America**	
Post Office Address **4 Hamaapilim St., Jerusalem, ISRAEL**	

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Second inventor's signature Ilan Kleinberger	Date 7/12/00
Residence **4 Hamaapilim St., Jerusalem, ISRAEL**	
Citizenship **United States of America**	
Post Office Address **4 Hamaapilim St., Jerusalem, ISRAEL**	

Full name of third inventor, if any Jack Yehoshua Mantinband	
Third inventor's signature J. Y. Mantinband	Date 7/12/00
Residence 31 Ezra St., 90 435 Efrat, ISRAEL	
Citizenship United States of America	
Post Office Address 31 Ezra St., 90 435 Efrat, ISRAEL	

Full name of fourth inventor, if any Hillel Goldberg	
Fourth inventor's signature Hillel Goldberg	Date 7/12/00
Residence Shivtei Yisrael 2/1, 99 522 Bet Shemesh, ISRAEL	
Citizenship United States of America	
Post Office Address Shivtei Yisrael 2/1, 99 522 Bet Shemesh, ISRAEL	

Full name of fifth inventor, if any	
Fifth inventor's signature	Date
Residence	
Citizenship	
Post Office Address	

Full name of sixth inventor, if any	
Sixth inventor's signature	Date
Residence	
Citizenship	
Post Office Address	

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) AND 1.27 (c)) - SMALL BUSINESS CONCERN	Docket No. 3Ality-008

Serial No.	Filing Date	Patent No:	Issue Date

Applicant/ Patentee: Kleinberger, et al

Invention: Stereoscopic Systems Based on Color Filters

I hereby declare that I am:

☐ the owner of the small business concern identified below:
☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN: 3Ality, Inc.
ADDRESS OF CONCERN: Ehrenreich Eilenberg Krause & Zivian LLP, 11 East 44th St, New York, NY 10017

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the above identified invention described in:

☒ the specification filed herewith with title as listed above.
☐ the application identified above.
☐ the patent identified above.

If the rights held by the above-identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed on the next page and no rights to the invention are held by any person, other than the inventor, who could not qualify as an independent inventor under 37 CFR 1.9(c) or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern or organization to which I hav assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

- ☒ no such person, concern or organization exists.
- ☐ each such person, concern or organization is listed below.

FULL NAME ______
ADDRESS ______
☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

FULL NAME ______
ADDRESS ______
☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

FULL NAME ______
ADDRESS ______
☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

FULL NAME ______
ADDRESS ______
☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING: Jack Yehoshua Mantinband
TITLE OF PERSON SIGNING OTHER THAN OWNER: President
ADDRESS OF PERSON SIGNING: 31 Ezra St., 90 435 Efrat, ISRAEL

SIGNATURE: J. Y. Mantinband DATE: 7/12/00

Figure 1

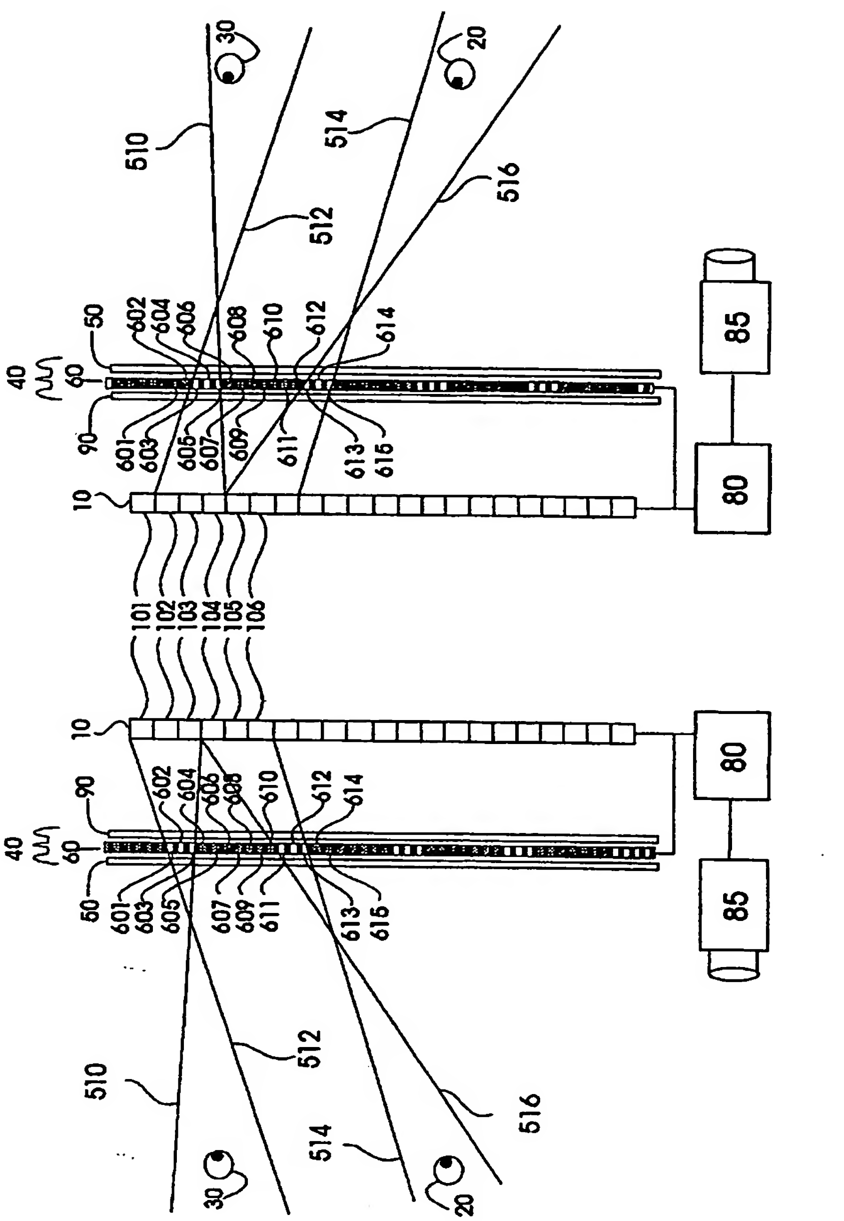

Figure 1a

Figure 1b

Figure 2

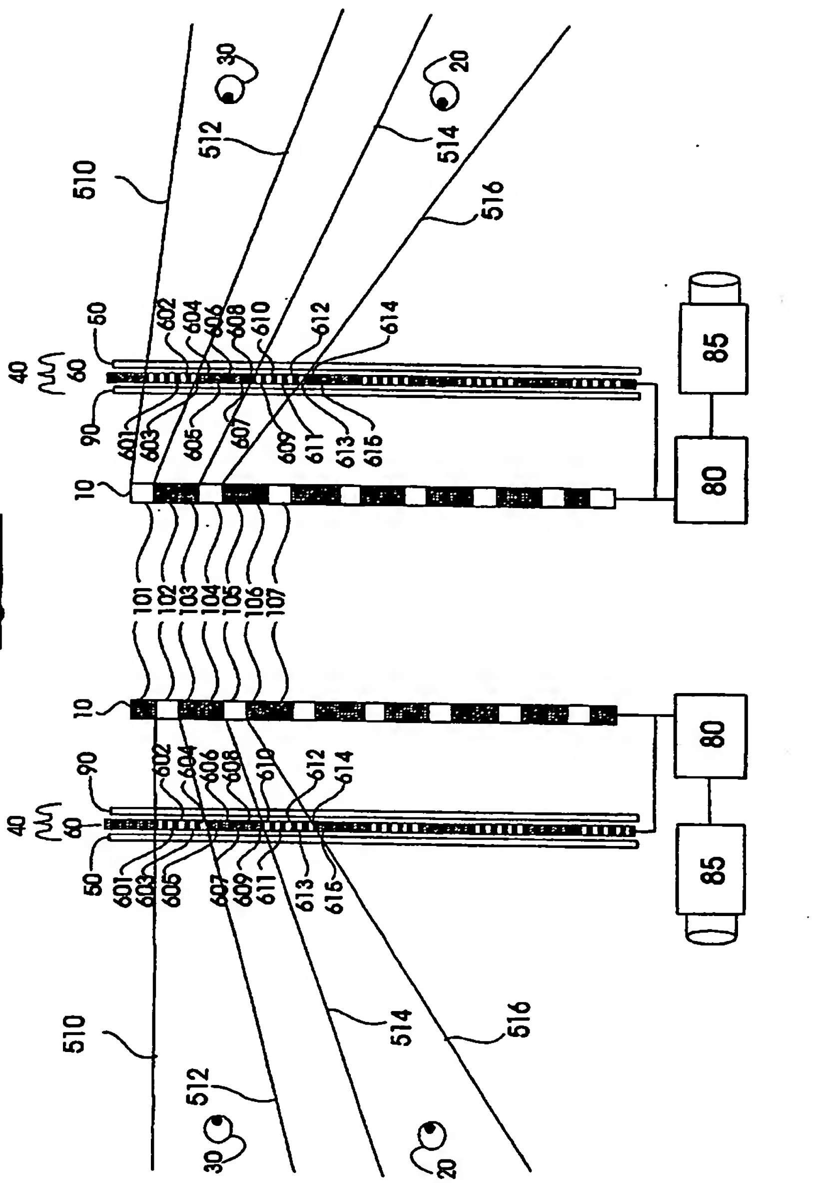

Figure 2a

Figure 2b

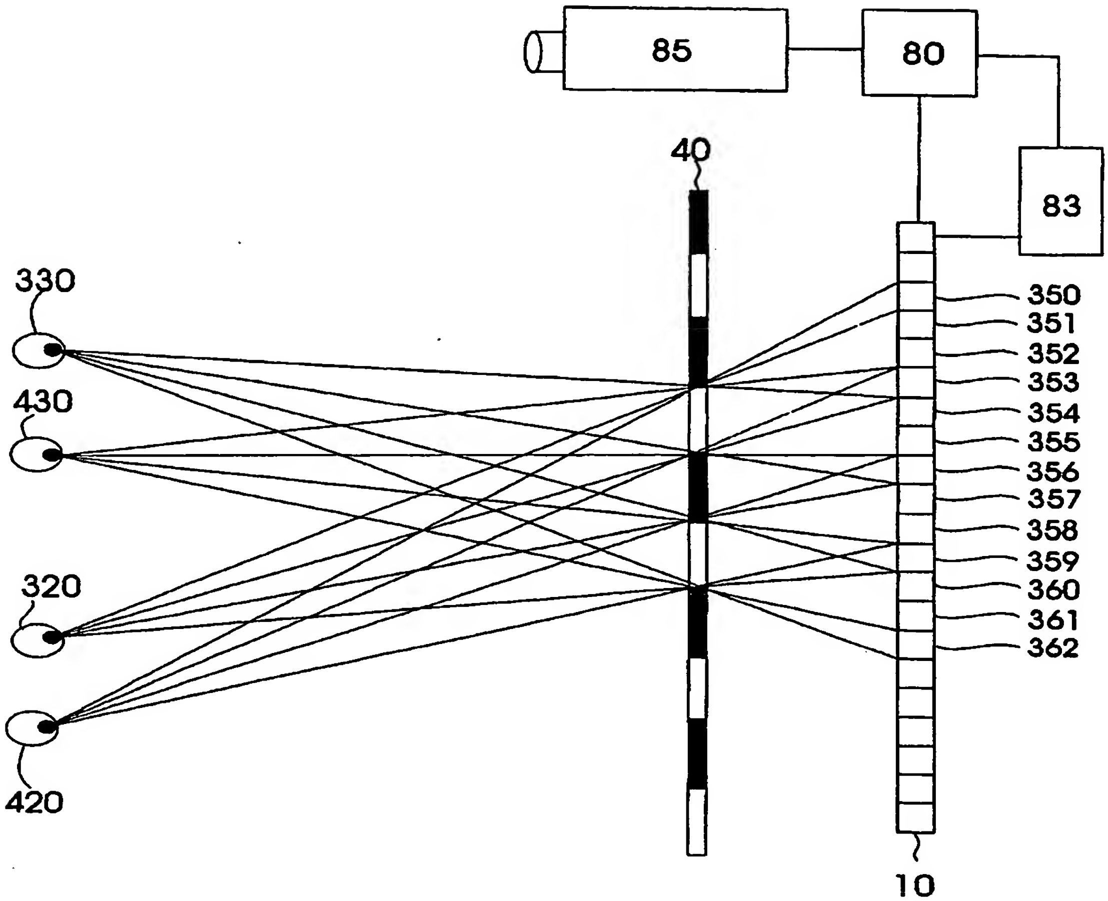
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Figure 3

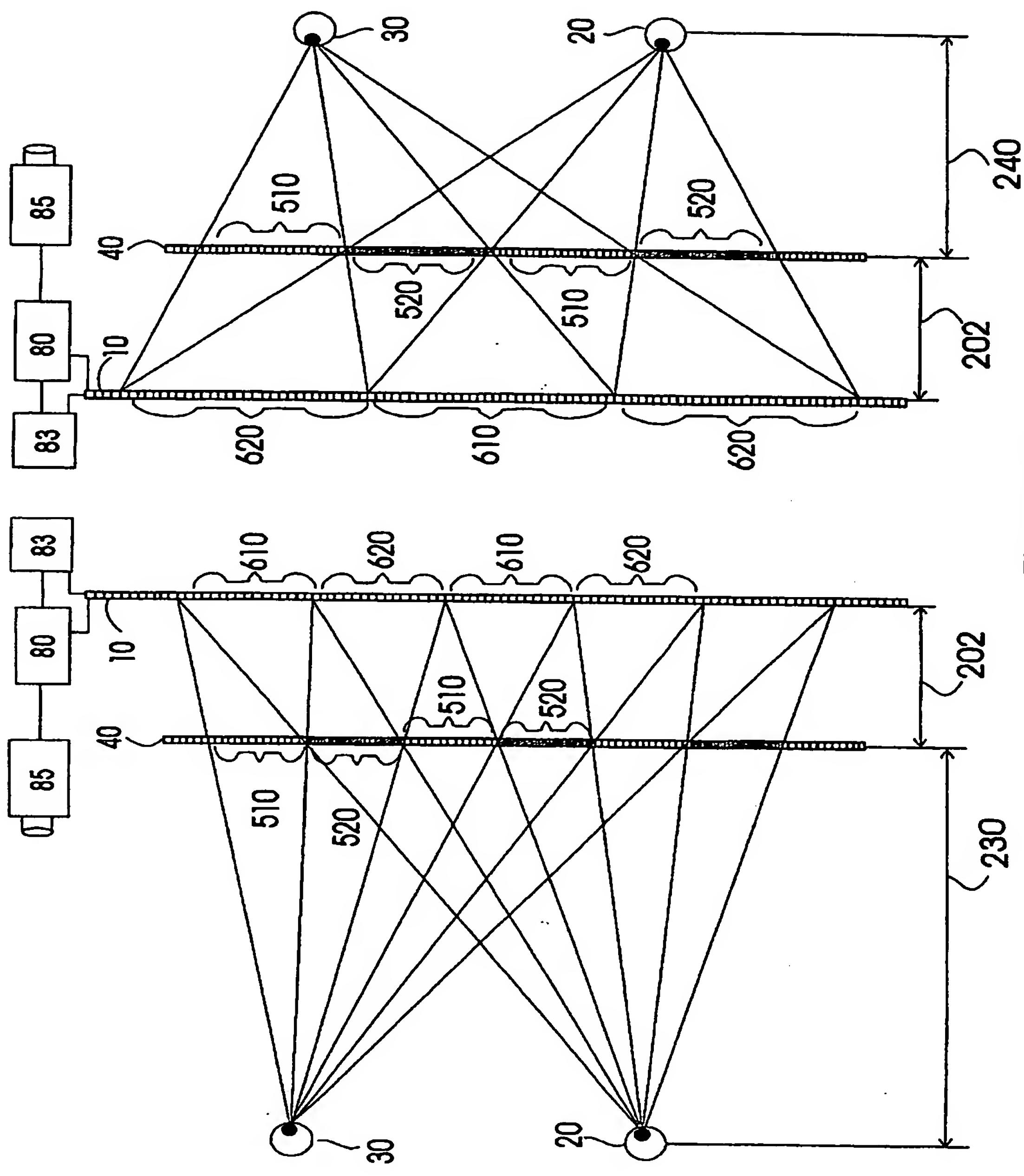


Figure 4

Figure 4a

Figure 4b

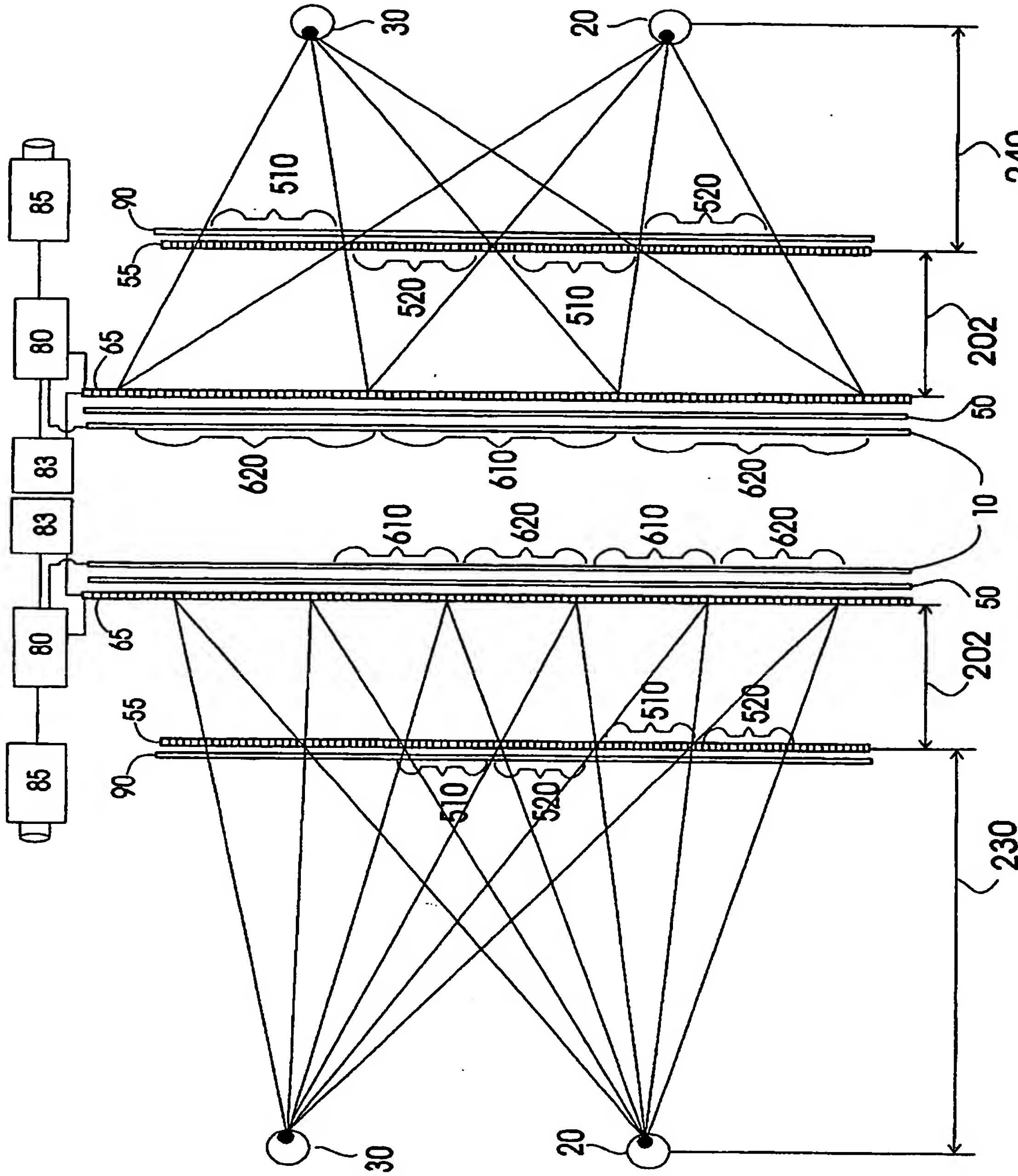
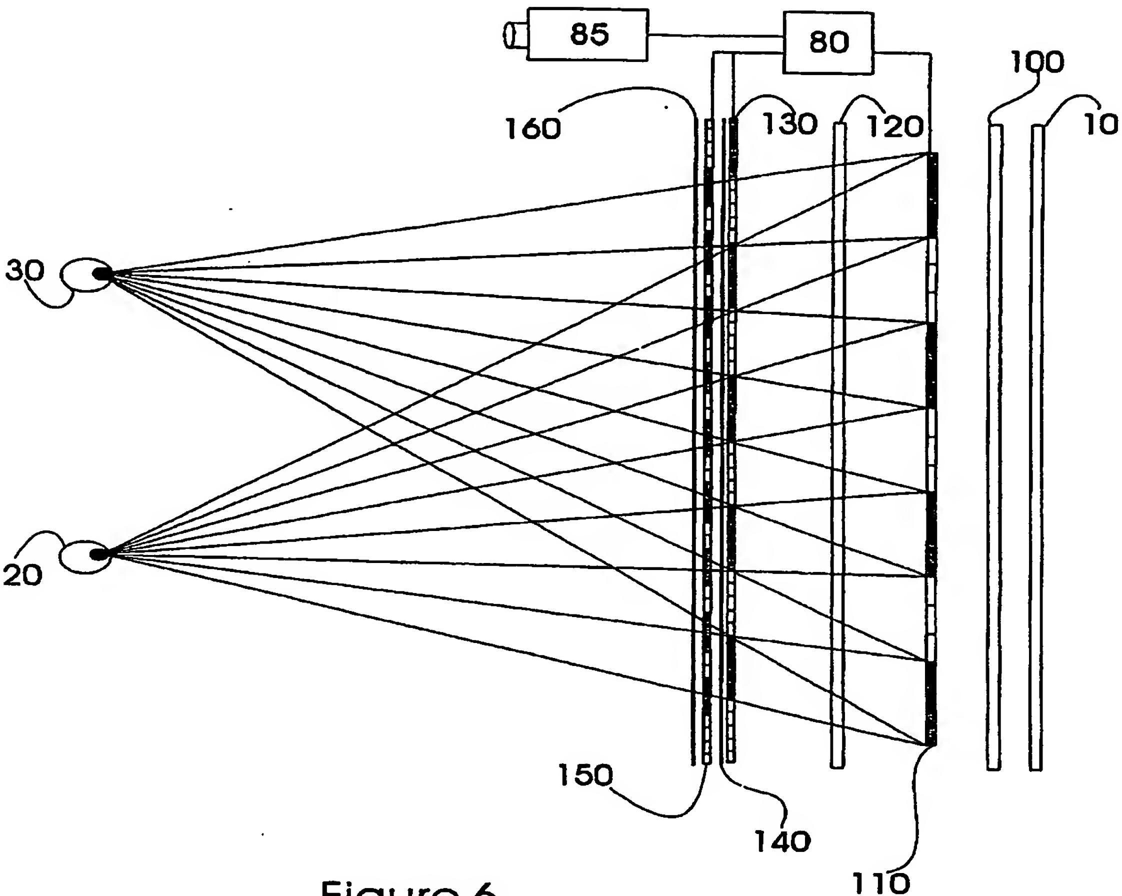


Figure 5

Figure 5a

Figure 5b



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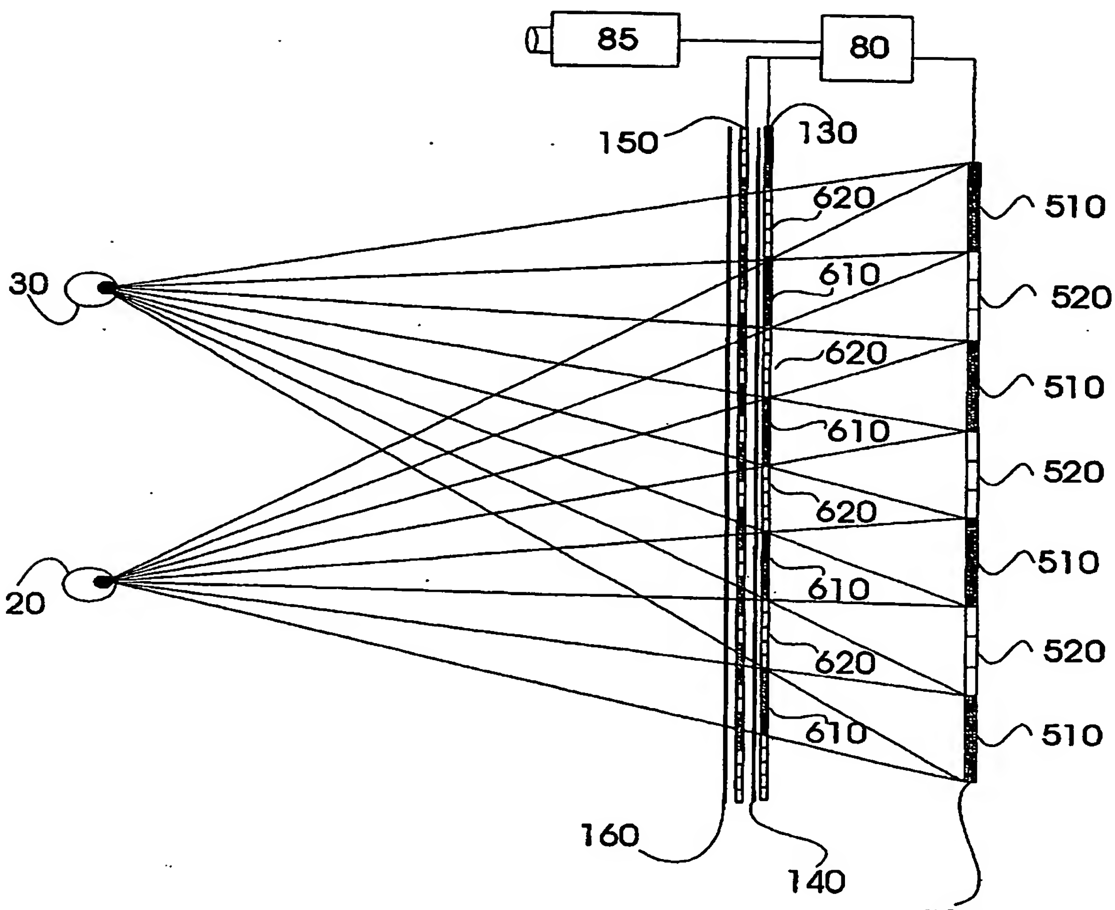
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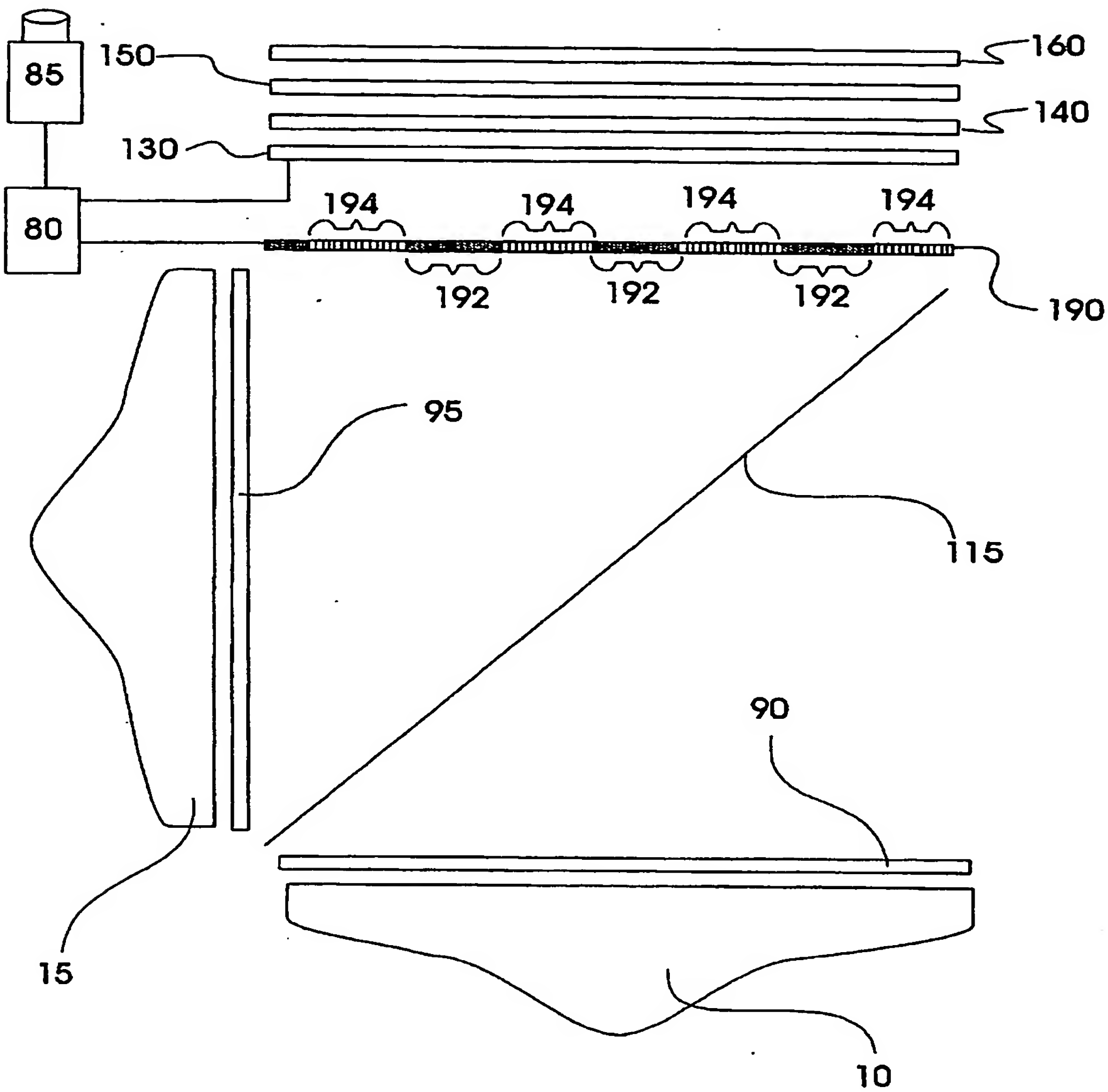
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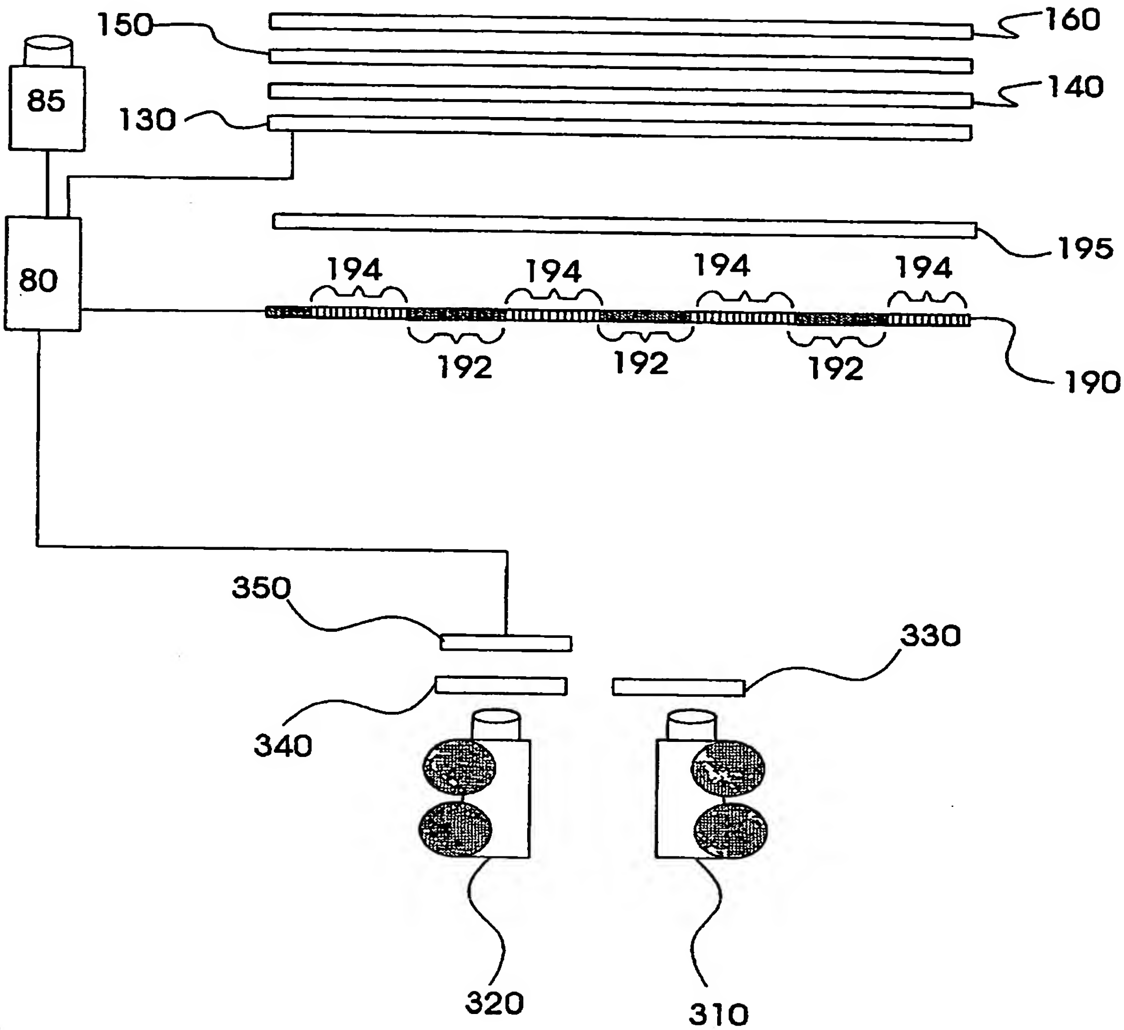
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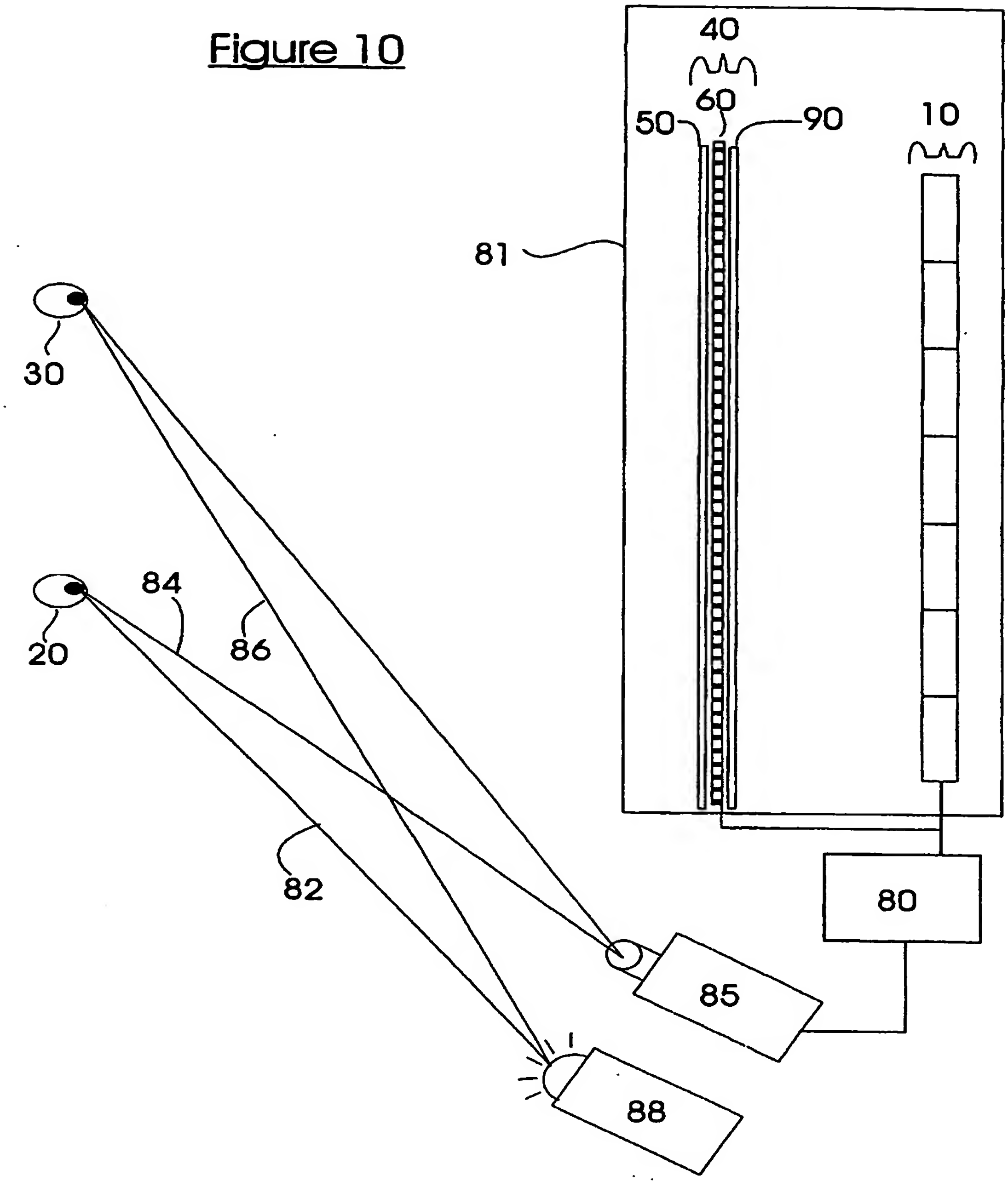
Figure 9

Figure 10



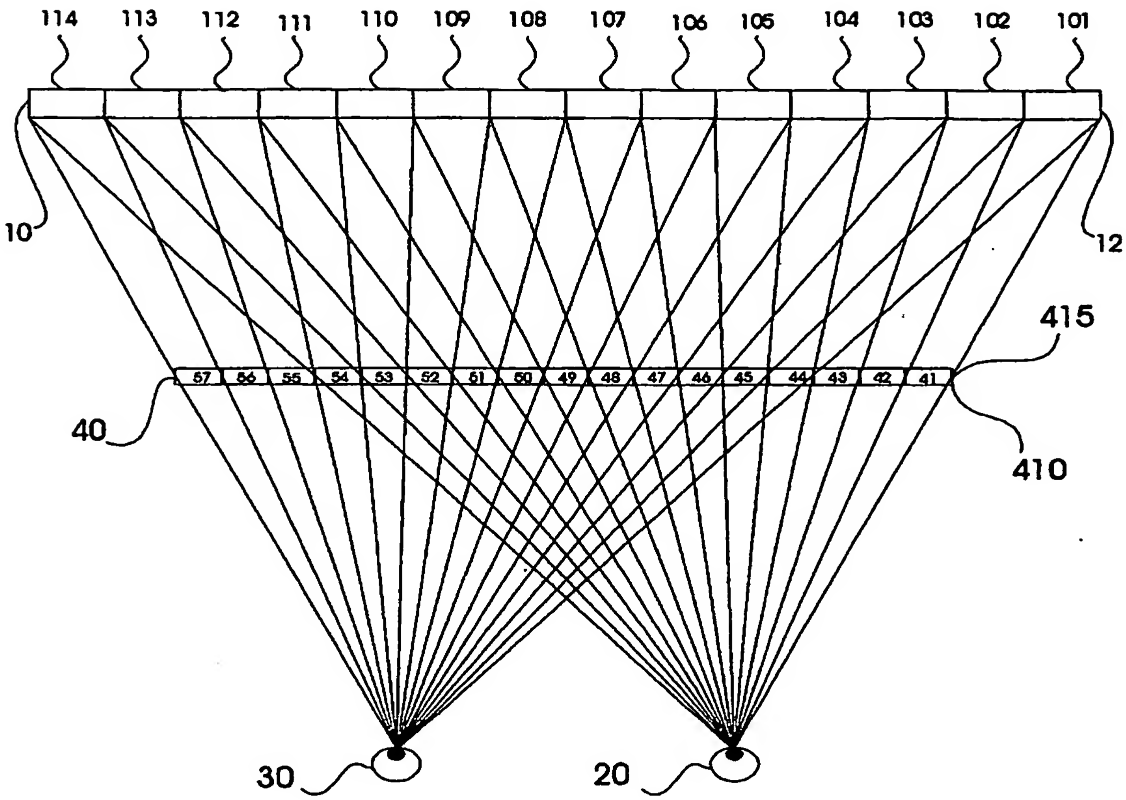

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Figure 11

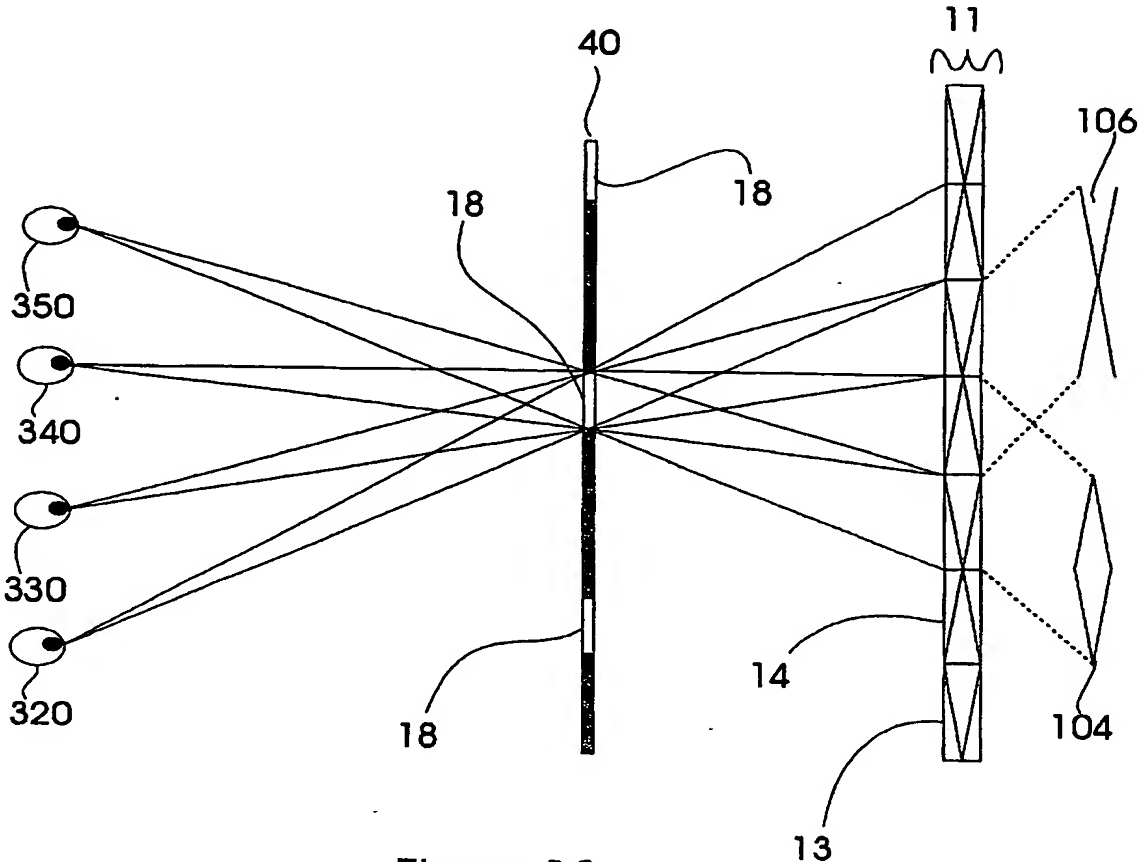
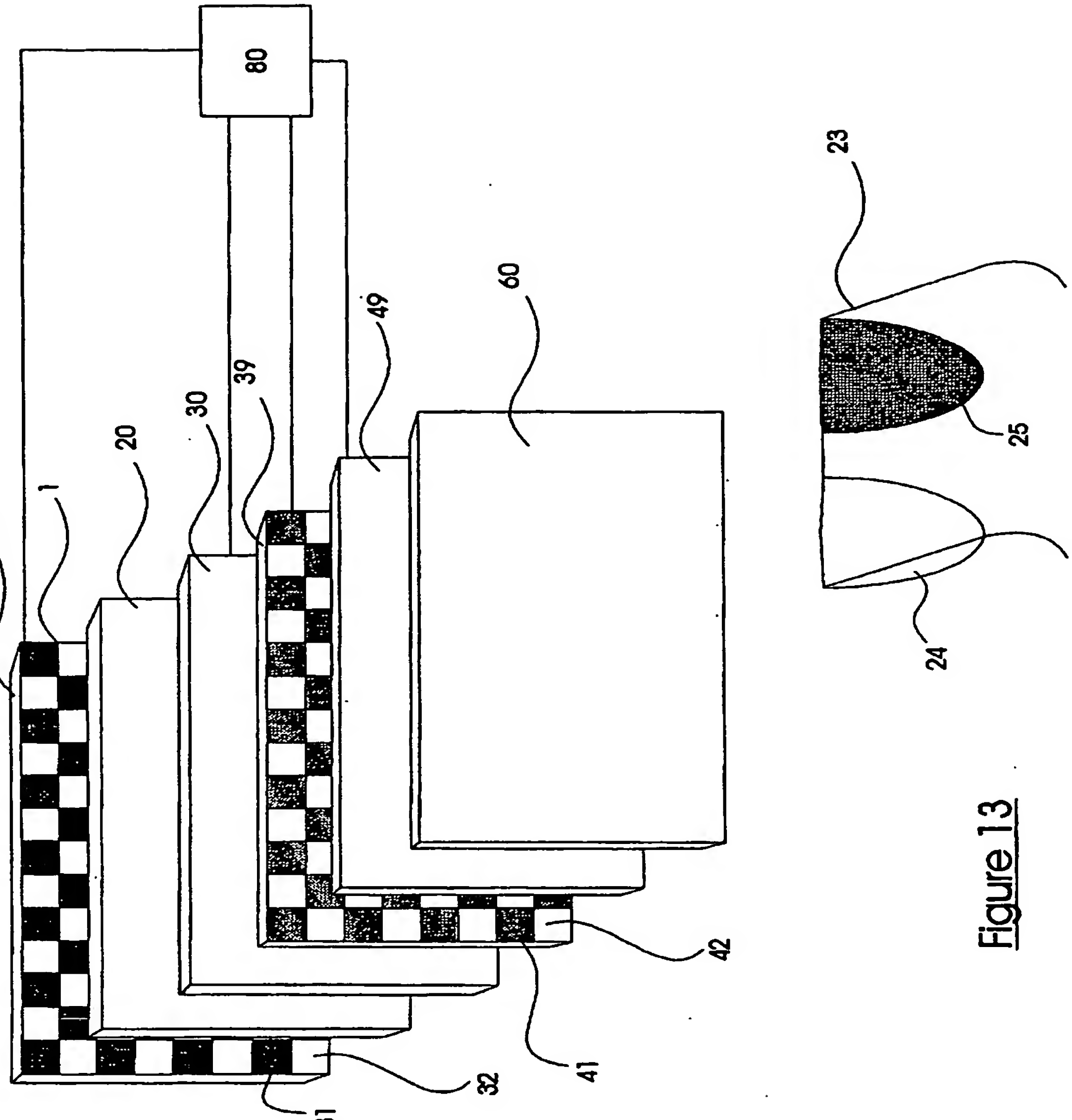


Figure 12

09/183387



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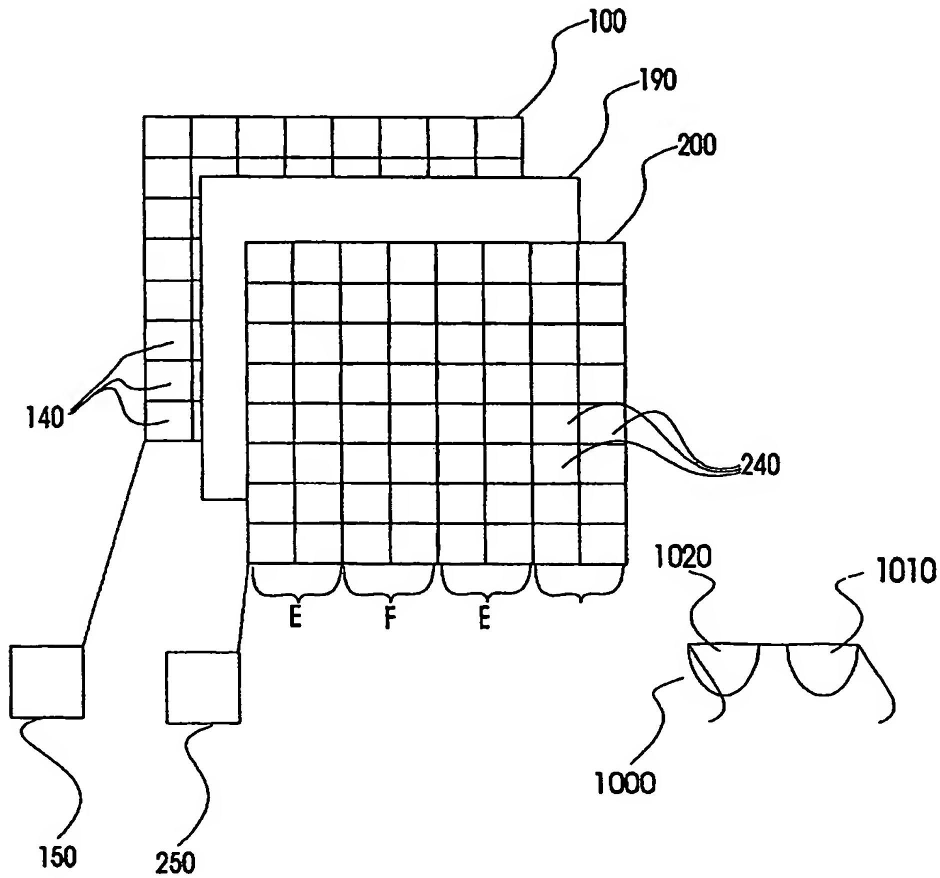

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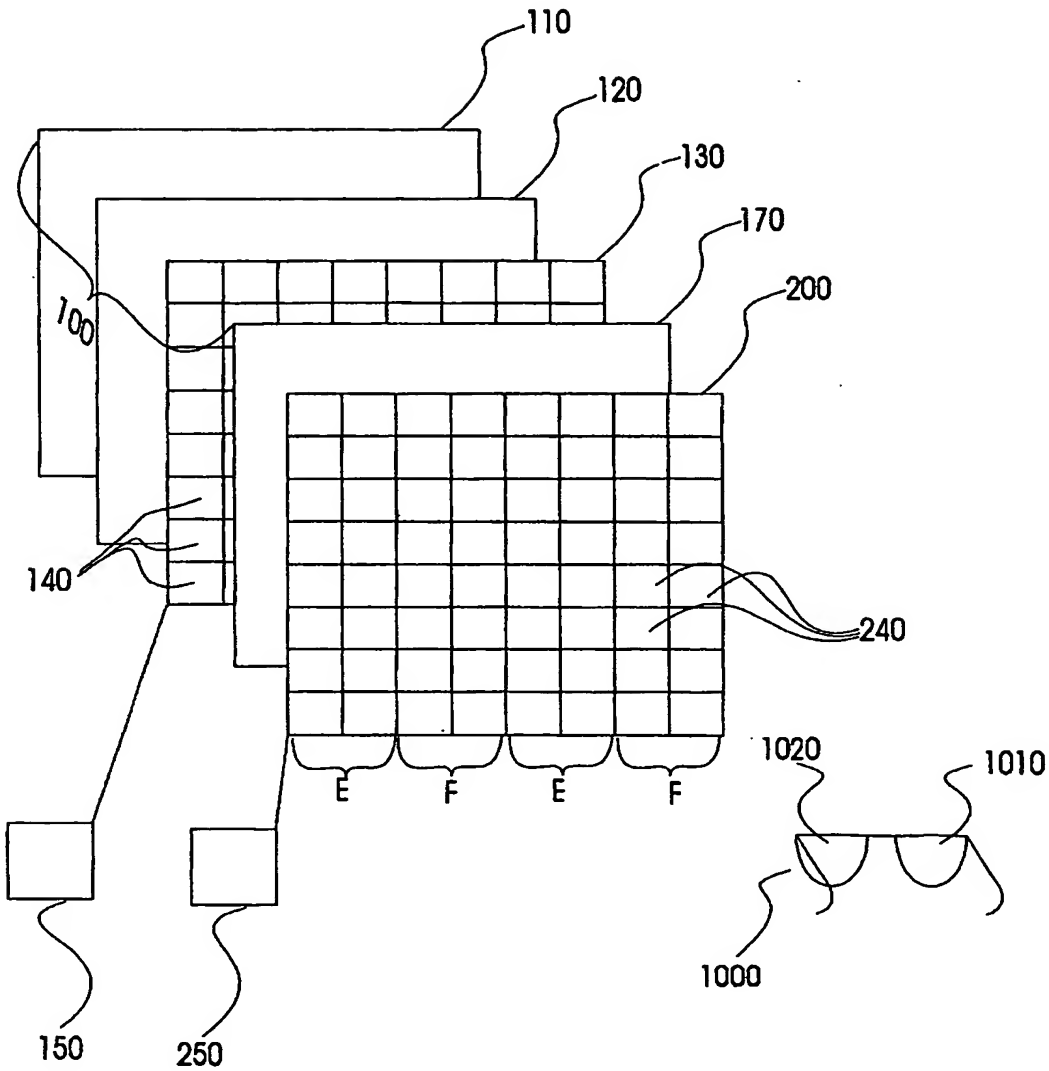
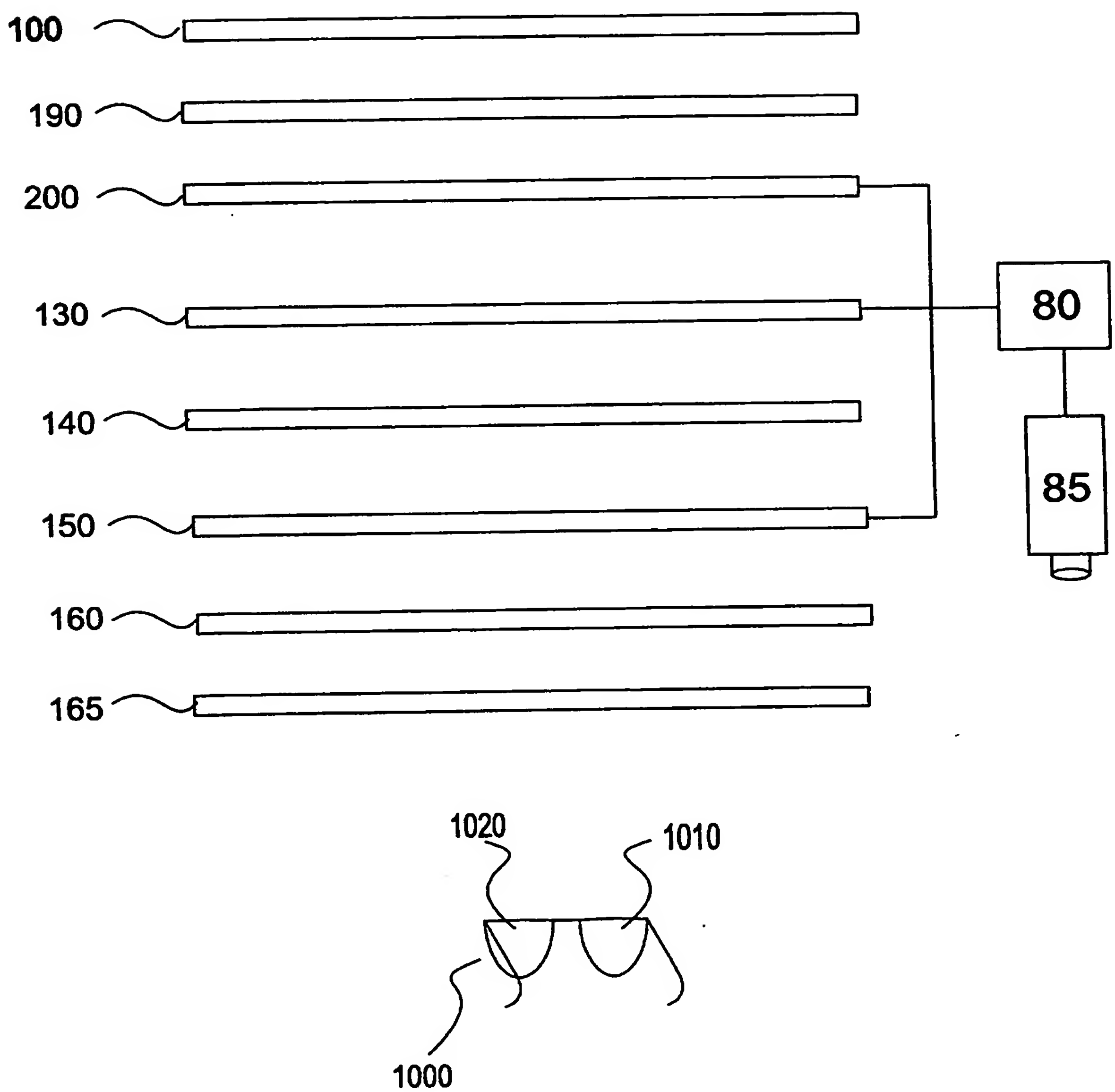
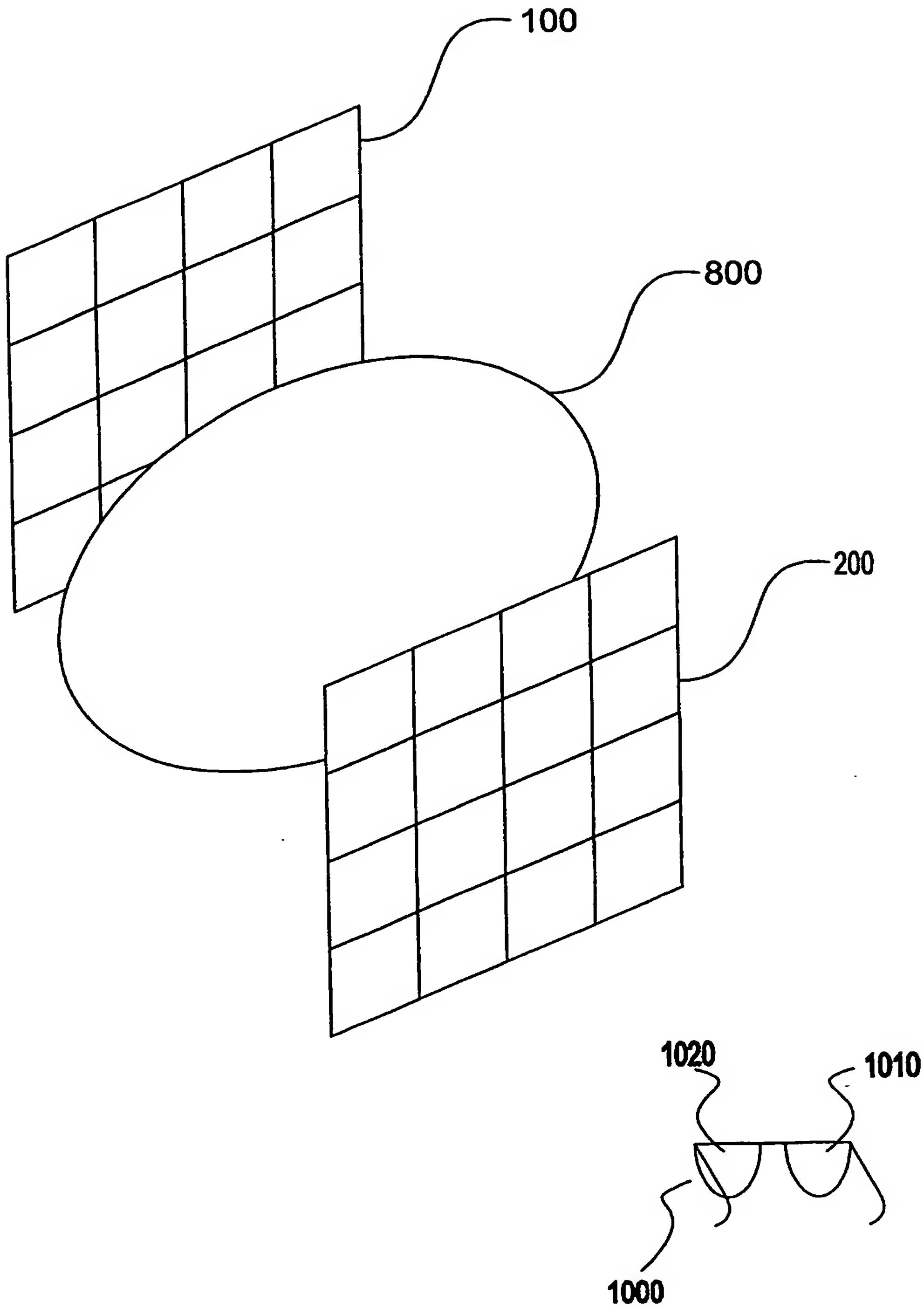


Figure 15

Figure 16





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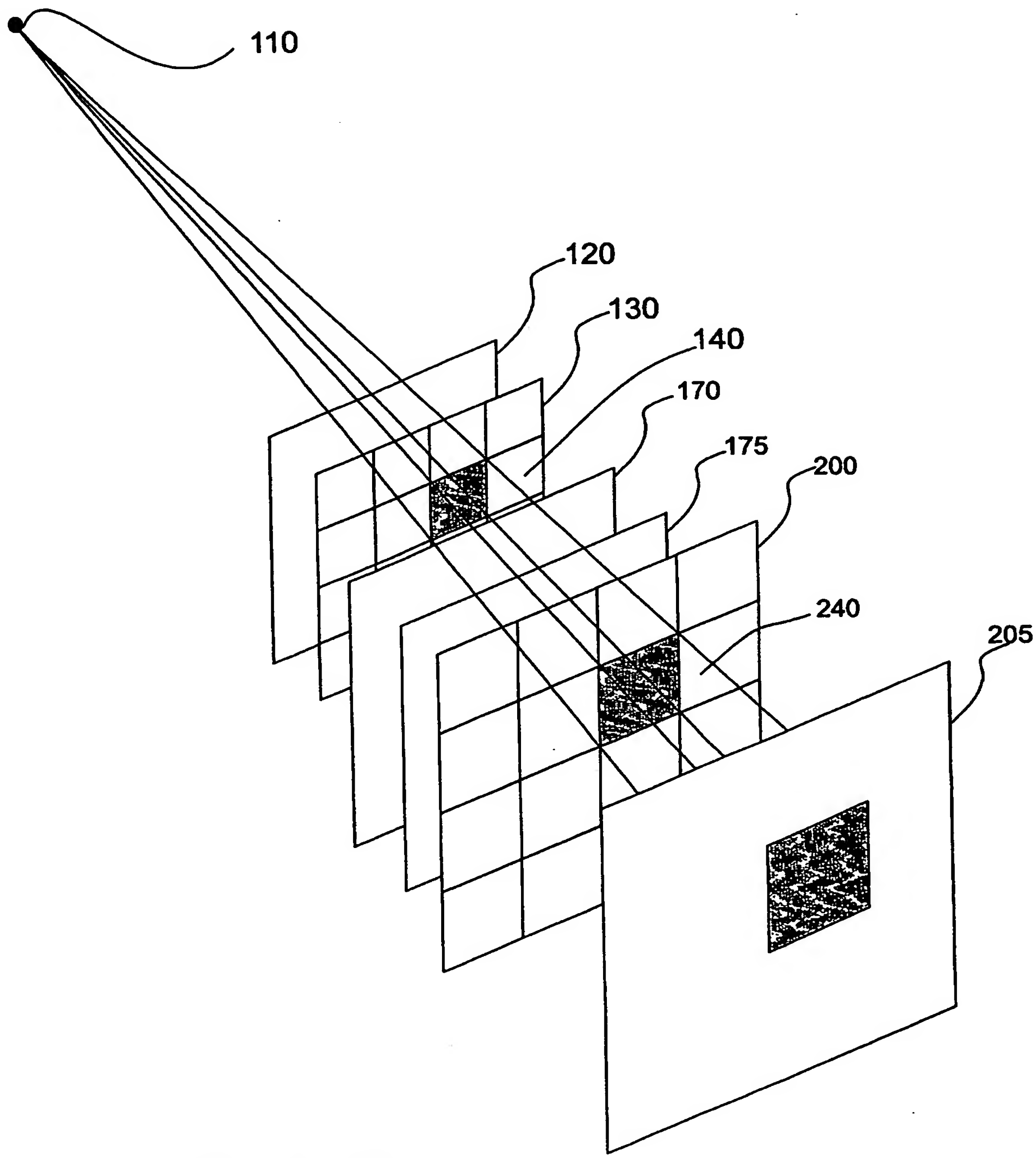

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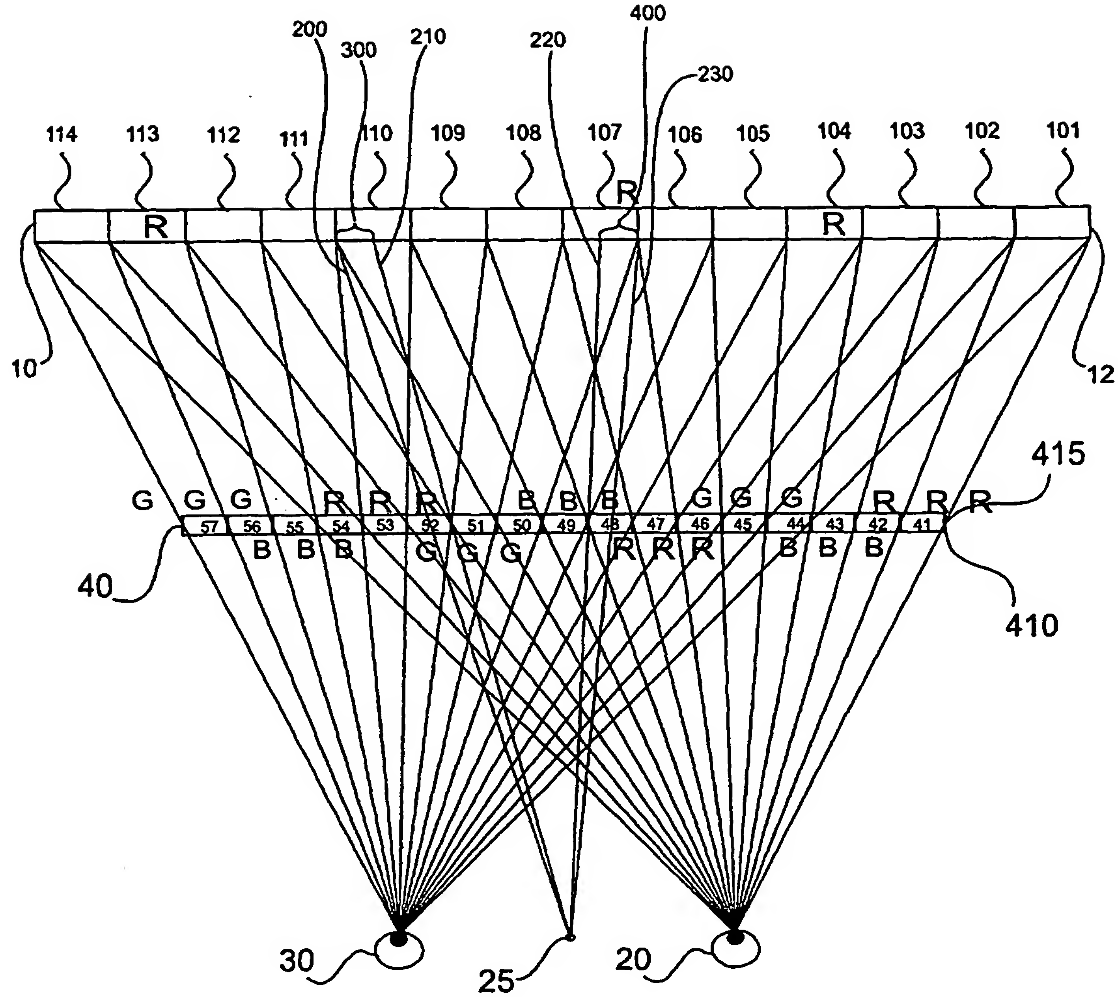
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Figure 19

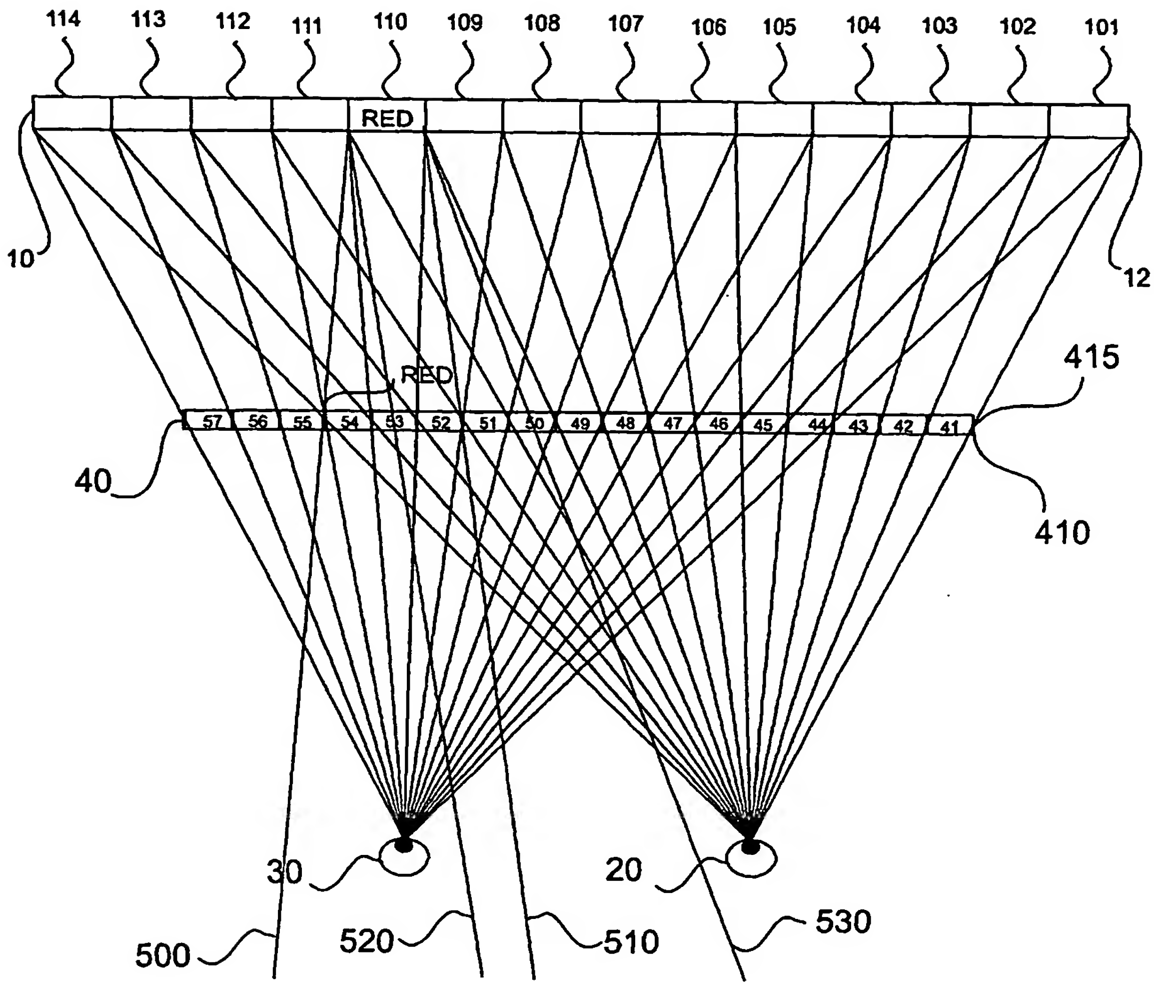
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Figure 20

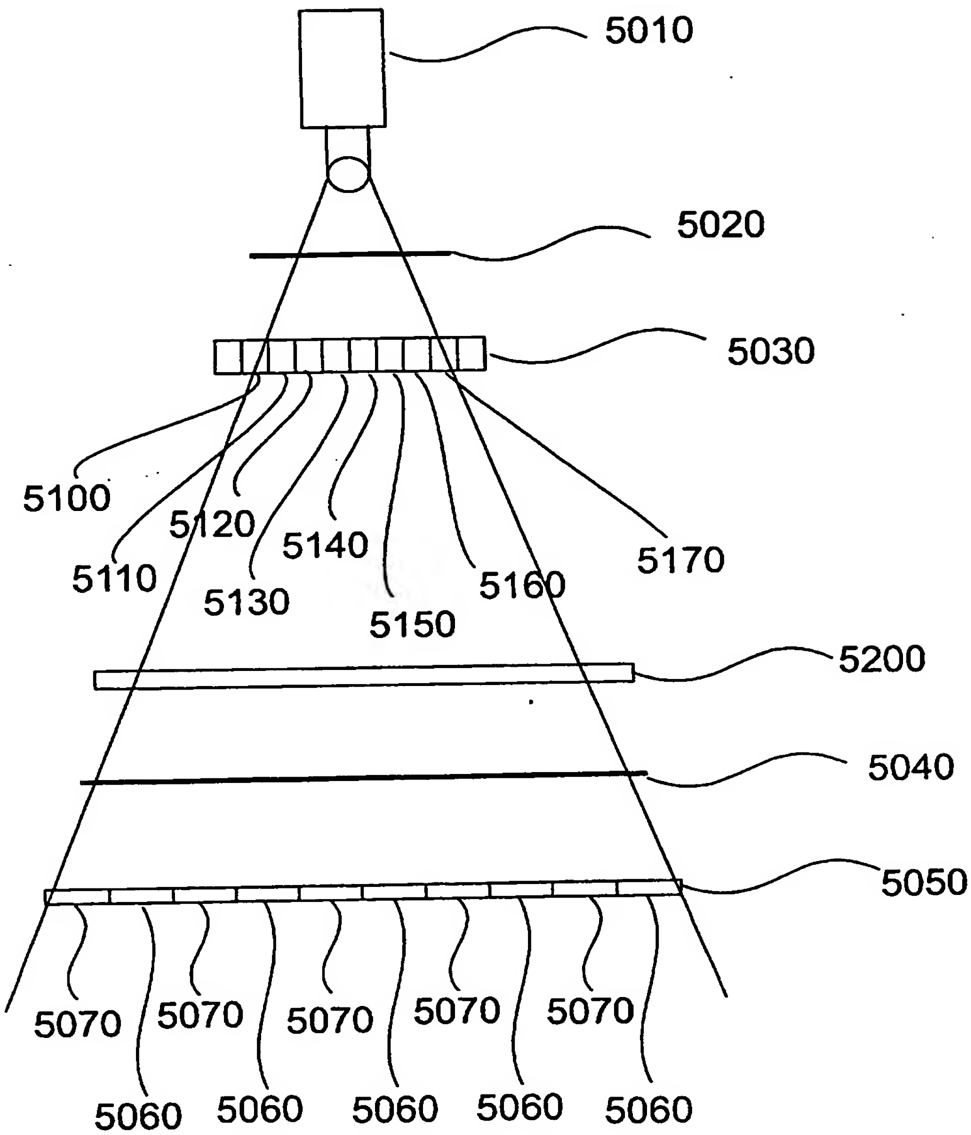

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Figure 21